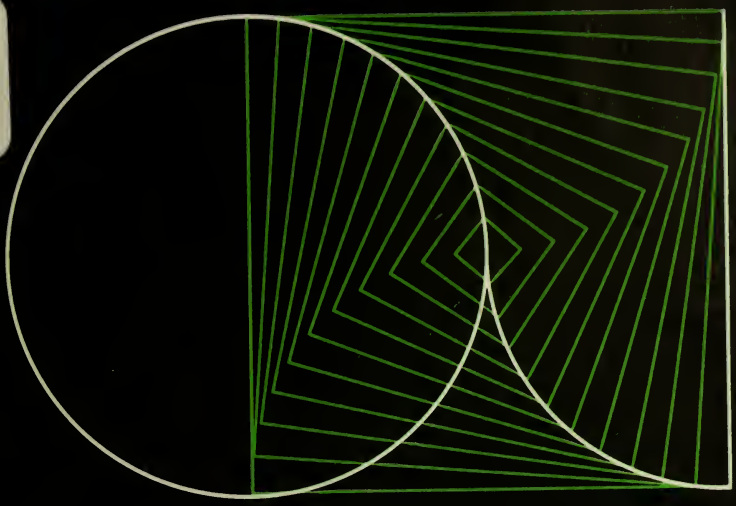

GRADUATE STUDY AND RESEARCH IN CIVIL AND SANITARY ENGINEERING

UNIVERSITY OF ILLINOIS BULLETIN JANUARY, 1967

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UNIVERSITY OF ILLINOIS CENTENNIAL YEAR 1967-1968

A Promising Future
through Graduate Study and Research

GRADUATE STUDY AND RESEARCH

IN CIVIL AND SANITARY ENGINEERING

DEPARTMENT OF CIVIL ENGINEERING
UNIVERSITY OF ILLINOIS, URBANA

JANUARY, 1967

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INTRODUCTION

The University of Illinois at Urbana, Illinois, was founded March 2, 1868, under the Land Grant College Act signed by Abraham Lincoln. In 1870, the College of Engineering was established. In 1871, the Department of Civil Engineering was organized and in 1872, four civil engineers were graduated.

Throughout these ninety-five years, the department has grown and maintained a high position among the best universities in the nation. Such excellence reflects the outstanding quality of the faculty, who offer the best in education at all levels, along with their significant contributions to research. In May, 1966, the American Council on Education, in its report entitled "An Assessment of Quality in Graduate Education," recognized the distinguished reputation and prestige earned by the department. Graduate departments in all areas, including engineering, were rated by the American Council on Education. The Department of Civil Engineering graduate faculty was rated "distinguished." The department was rated the highest in the distinguished category at the University of Illinois and second in the country in the field of civil engineering.

The future for civil engineering at the University of Illinois is more promising than ever before, as the new multi-million dollar facilities specially designed for graduate training and research are presently being completed and occupied.

The department offers challenging opportunities to qualified students working towards advanced degrees. Formal course work and participa-

tion in creative research enable the civil engineer with graduate training to go beyond the normal limitations imposed by the baccalaureate degree and to be better prepared to contribute to the progress of his profession. The graduate program places special emphasis on research training in the belief that this is one of the most valuable kinds of scientific engineering experience and training which can be gained by the student.

Recent scientific and industrial developments and the increasing complexity of many phases of engineering have created a strong demand for civil and sanitary engineers with formal study beyond that offered in undergraduate programs. Among the fields of work for which graduate study is desirable and for which it prepares the engineer are: advanced analysis and design; consulting engineering practice; teaching of both fundamental and advanced courses in civil engineering, mechanics, and related fields; research and development in industrial laboratories, educational and scientific institutions, and governmental laboratories; and administrative responsibilities in various specialized fields.

This catalog contains essential information for those considering graduate study in civil and sanitary engineering. It is recognized that some of the brief statements may generate questions. Students are encouraged to correspond with the head of the department on specific problems or questions. Address inquiries to:

Head, Department of Civil Engineering
Civil Engineering Building
University of Illinois
Urbana, Illinois 61801

Advanced study, research, and professional training are offered in the following fields of civil and sanitary engineering: Air Pollution . . . Analysis and Design of Structures . . . Behavior of Structures and Properties of Structural Materials (Concrete, Steel, etc.) . . . Construction Engineering and Management . . . Digital Computer Applications to Analysis or Design . . . Geodetic Engineering . . . Health Physics . . . Highway Engineering . . . Hydrology . . . Hydromechanics and Hydraulic Structures . . . Materials and Structural Design of Roadways . . . Models Research . . . Nuclear Structural Shielding . . . Photogrammetry and Photogrammetric Engineering . . . Radiological Health . . . Railway Engineering . . . Rock Mechanics . . . Soil Mechanics and Foundations . . . Stream Analysis . . . Structural Dynamics: Design for Earthquake, Shock, and Blast Excitation . . . Structural Mechanics . . . Systems Analysis and Design . . . Traffic Engineering . . . Transportation: Plan-

ning, Systems Design, and Operations . . . Urban Planning and Management . . . Waste Water Treatment . . . Water Quality and Treatment . . . Water Resources.

Because of the extensive research programs directed by members of the staff in these and in related fields, excellent facilities for research are available for use by graduate students.

The degrees of Master of Science and Doctor of Philosophy may be attained by qualified students who satisfy the requirements of the department and the Graduate College. Progress toward an advanced degree is measured not only by the acccumulation of units of credit in formal course work but also by evidence of intellectual growth and achievement. The main purpose of graduate study is to enable a student to broaden his knowledge of, and increase his competence in, a given field. Graduate study, especially in the second and third years of the doctorate, aims at the development of independent scholarship, originality, and competence in research, coupled with development of engineering judgment. Training of this type is fostered by close and frequent contact between the student and academic staff. The students' advisers in research and graduate studies in civil engineering are among the most eminent engineering teachers in the country. Because almost all staff members are directly involved in research, and are advisers to a relatively small number of students, close individual contact exists.

The large enrollment of graduate students from all parts of the world not only adds to the stature of the department, but also it makes it possible to offer a wide range of courses on all phases of civil and sanitary engineering. Graduate students in civil engineering at the University of Illinois are selected from the top students in the United States and foreign countries. The many domestic and foreign students contribute to the department a variety of experience, which broadens the outlook of all who are included in the graduate group. The knowledge and friendship gained from contact with this select group will be of importance and advantage to the student in his future career.

The staff, graduate students, and technicians in the Department of Civil Engineering are shown for the spring of 1966:

Full Professors	35	Graduate Students, including Research Assistants and Fellows	265
Associate Professors	16		
Assistant Professors	27	Technicians and Student Employees	40
Instructors	6		
Postdoctoral Fellows	1	Secretaries and Others	40

The number of degrees awarded by the department in recent years is summarized below.

Degrees Awarded	*1962*	*1963*	*1964*	*1965*	*1966*
B.S.	101	98	131	117	96
M.S.	81	98	113	106	99
Ph.D.	28	19	42	20	39

Extensive research programs, involving an annual expenditure of almost two million dollars, enable students to participate in active research projects. Research is supported by the University as a part of its educational program for advanced undergraduate and graduate students. However, a large part of the research and graduate program is supported by special grants from various sponsors, including federal and state agencies, technical societies, professional associations, and research councils. Present sponsors include American Iron and Steel Institute . . . Atomic Energy Commission . . . Automotive Safety Foundation . . . Champaign-Urbana Sanitary District . . . Chicago Bridge and Iron Foundation . . . Defense Atomic Support Agency . . . Department of the Air Force: Weapons Laboratory; Ballistic System Division . . . Department of the Army: Army Materiel Command; Corps of Engineers; Waterways Experiment Station . . . Department of Commerce: Bureau of Public Roads . . . Department of Defense: Office of Civil Defense . . . Department of Health, Education, and Welfare: Public Health Service . . . Department of the Interior: Bureau of Reclamation; Federal Water Pollution Control Administration . . . Department of the Navy: Naval Facilities Engineering Command; Naval Ship Systems Command; Office of Naval Research; Radiological Defense Laboratory . . . Esso Research Engineering Company . . . Industrial Fasteners Institute . . . International Lead Zinc Research Organization Incorporated . . . National Academy of Sciences–National Research Council: Highway Research Board; Ship Structure Committee . . . National Science Foundation . . . National Steel Corporation . . . New York Central Railroad Company . . . Portland Cement Association . . . Raymond Concrete Pile Company . . . Research Council on Riveted and Bolted Structural Joints . . . Resources for Future . . . State of Illinois: Department of Conservation; Division of Highways . . . United Engineering Trustees Incorporated . . . United States Steel Corporation . . . Welding Research Council.

ADMISSION

Admission to the Graduate College with full status in civil or sanitary engineering is granted to graduates of institutions whose requirements for the bachelor's degree are substantially equivalent to those of the University of Illinois, provided the applicant's preparation is appropriate to advanced study in his chosen major field and his scholastic average is at least 4.0.[1] This average is computed on the basis of the last sixty semester hours, or 110 quarter hours, of credit recorded.[2] In computing grade-point averages, evidence that the school's grading system is based on a different datum is considered. Under certain conditions applicants with a grade-point average of less than 4.0, and applicants from schools with different grading systems, may be considered if their average is at least the equivalent of 3.75 and evidence is submitted indicating that the applicant's ability is not appropriately measured by the grades submitted. Such applicants should have their application accompanied by at least two letters of recommendation regarding their ability, and by such other evidence that they wish to submit.

Admission to graduate courses may be granted only to those who have had the requisite undergraduate work in those courses. Students without adequate preparation may be required to take, without credit, certain undergraduate courses.

Students from the United States. Students who are citizens of the United States can obtain admission application forms from the Graduate College, the Office of Admissions and Records, or the Department of Civil Engineering. Students should request, if needed, a copy of the Graduate College catalog and the pamphlet entitled *The Road to Graduate School* when the application forms are requested. To avoid delays, a prospective student is urged to submit his application at least three months in advance of the opening of the session in which he plans to enroll.[3] Students from a country other than the United States should make application by letter in accordance with instructions given below. A student whose native language is not English should submit his application at least three months (preferably five months) prior to the anticipated registration

[1] In converting to a numerical grade, the following equivalents are used: A = 5; B = 4; C = 3; D (minimum passing grade) = 2.

[2] All hours of credit are included for all courses in the semesters, quarters, or summer sessions involved in the last sixty semester hours, or 110 quarter hours, of undergraduate work and accordingly the total of hours used in the average may be greater than that noted. Courses failed and subsequently passed must also be included.

[3] For approximate enrollment date, see the calendar on page 69.

date. An official transcript from each undergraduate college attended must be forwarded. In addition, all graduate students entering the Department of Civil Engineering must arrange to have one additional set of transcripts forwarded to the department office for its records and use. Transcripts of students who enter the Graduate College can not be returned. An official statement of rank in class, and rank in college, also should be submitted.

Students from Foreign Countries. Students must be able to understand and be understood in English, both written and oral. This ability is tested in the applicant's own country with an English examination. Instructions concerning the test, if required, are sent to the applicant soon after his credentials have been received and evaluated. A placement examination in English is required at the time of registration on the campus. When indicated by the placement test, non-credit English courses are prescribed, which reduce accordingly the registration in credit courses and extend the time for completing degree requirements. Applicants who can present evidence that they satisfy the above requirements for language proficiency should submit a letter requesting admission, giving the following information in English:

1. Your full legal name.
2. Address to which reply should be mailed.
3. Place and date of birth.
4. Name of the country of which you are now a citizen.
5. Subject in which you wish to specialize.
6. Your native language.
7. Whether you wish to be a candidate for an undergraduate or a graduate degree.
8. Amount in United States dollars available for your support, the source of your income, and the length of time this support is guaranteed. Before admission is granted each student is asked to present evidence that he has sufficient money to meet his expenses while attending the University of Illinois. *Do not send any money until notified to do so.*
9. A complete chronological list of all secondary schools and colleges attended, dates, and diplomas or certificates or degrees received. *Please enclose official copies of your academic credentials.*
10. If you are not attending school, your occupation since leaving school.
11. Date you plan to enter the University of Illinois.

The Director of the Office of Foreign Student Affairs, 310 Student Services Building, University of Illinois, Champaign, Illinois 61820,

U.S.A., assists students from abroad with problems involving passports, visas, and other matters.

Admission with Advanced Standing. Upon the recommendation of the head of the department and with the approval of the Dean of the Graduate College, admission with advanced standing is granted to applicants who have completed a master's degree or the equivalent elsewhere and who desire to become candidates for the doctor's degree at the University of Illinois. A candidate for admission with advanced standing must meet the minimum standards noted above, and must exhibit an excellent record in his advanced work. The department desires, and may require, that a student supply in support of his application for advanced standing an official record of his Aptitude and Advanced Engineering scores in the Graduate Record Examination administered by the Educational Testing Service, P.O. Box 955, Princeton, New Jersey 08540, U.S.A. The record supplied must be for an examination taken during the preceding year.

The amount of credit to be accumulated at the University of Illinois before the candidate is admitted to the preliminary examination can be determined only by the advisers in the major and minor fields after the student has registered and completed some work here.

Professor S. J. Fenves (left) and Professor L. R. Shaffer (right) discuss a computer program with Assistant Professor L. S. Murphree, Jr., in the civil engineering systems laboratory.

REGISTRATION AND PROGRAM OF STUDIES

Registration. Dates for registration in the Graduate College are shown on the abbreviated calendar on page 69. Registration material and special instructions are available from the department office during the scheduled registration days or at any time thereafter.

Advisers. Each graduate student is assigned an adviser who assists in planning and carrying through a program of graduate work which fits his needs and satisfies departmental and Graduate College requirements. The adviser for research assistants is normally the staff member in charge of each assistant's research program.

Unit Credit for Courses. Courses offering graduate credit are numbered from 300 to 399 when they are open both to advanced undergraduates and to graduate students, and are numbered 400 and above when they are open only to graduate students.

Graduate credit is measured in terms of units. One unit is considered the equivalent of four semester hours. The normal program for a full-time graduate student is four units each semester; the maximum permissible is five units. The normal program for an eight-week summer session is two units, with two and one-half units being the maximum permitted.

The amount of credit which may be earned in individual courses is indicated in the course listing. The course credits for which the student is registered is entered on the student's program card by his adviser and is subject to the approval of the Dean of the Graduate College.

Work Completed Elsewhere. A candidate for the doctorate, who has received a master's degree from a recognized institution, receives credits for the equivalent of one year's study for that work. If such credit is to be used in partial fulfillment of the requirements for the doctorate, he is examined on the content of the courses involved at the time of the preliminary examination.

A graduate student who has done graduate work in a recognized institution, but without receiving a degree, may petition to obtain credit toward an advanced degree by passing examinations in this work. Admission to such examinations requires the approval of the department and of the Dean of the Graduate College. The acceptance of credit for work completed elsewhere does not reduce the residence requirement for the degree sought.

Upon recommendation of the department, the Graduate College may permit a student to register for work at a laboratory elsewhere that offers facilities not available in Urbana. Such work is accepted for graduate credit if it is completed satisfactorily.

Miscellaneous Courses. A student carrying a normal graduate program may elect, in addition, one miscellaneous course (a course which does not give credit toward an advanced degree). If a graduate student enrolls for more than one miscellaneous course, he may not register for a full graduate program. Courses intended to teach graduate students a reading knowledge of French, German, or Russian are regarded as miscellaneous courses. A student who elects a miscellaneous course is required to register in it and do the assigned work.

Auditing Privileges. A graduate student is permitted to attend classes (other than laboratory courses) as an auditor, provided a form bearing the approval of the instructor and the Dean of the Graduate College is filed with the Records Section of the Office of Admissions and Records. He may not take the same course at a later date for credit.

The creep properties of a bituminous mixture are being determined by Professor M. Herrin and a graduate student in the highway materials laboratory.

Graduate Programs for Employed Students. A student who is employed can not expect to complete his academic work as promptly as one who devotes full time to his academic program.

The academic work carried by assistants and others on the University staff is limited by statute. Those employed outside the University are expected to reduce their programs of work in accordance with these regulations. The maximum amount of academic work is determined by the terms of employment as follows:

	Maximum Registration	
Terms of Employment	*Semester*	*Summer Session*
Full time	1 unit	1 unit
Three-fourths time	2 units	1¼ units
Two-thirds time	2¼ units	1½ units
One-half time	3 units	1¾ units
One-third time	3¾ units	2 units
One-fourth time	4 units	2 units
None	5 units	2½ units

Under exceptional circumstances, additional registration is permitted by the Dean of the Graduate College.

Time Limit for Advanced Degrees. A candidate for the master's degree must complete all requirements for the degree within five calendar years after his first registration in the Graduate College.

A candidate for the doctor's degree must complete all requirements for this degree within seven calendar years after his first registration in the Graduate College, except as noted below.

A candidate for the doctorate who has received a master's degree elsewhere must complete all requirements for the degree within five years after his first registration in the Graduate College. This same regulation applies to the candidate who has received his master's degree from the University of Illinois and whose studies were interrupted immediately thereafter, provided not more than the minimum number of units required for the master's degree are applied to the doctorate.

In general, the transfer of graduate credit from other institutions under circumstances not specifically defined above is considered a basis for proportionate reduction of the time allowed for earning a degree.

Graduate Study in the Summer. A limited number of civil engineering graduate courses are offered during the summer session, usually in structures, soil mechanics, and foundations. The courses offered vary from summer to summer, so that by careful planning, it is often possible to complete the requirements for the master's degree by summer study and

make progress toward the doctor's degree. It is not possible to obtain a doctoral degree in civil engineering by attending only summer sessions.

Grades. Grades are recorded by letters as follows: for thesis research, S and U (satisfactory and unsatisfactory); for courses, A, B, C, D, and E (failure). A student with three units of grade below B is disqualified as a degree candidate. If he has received two but *less* than three units of grade below B, then all units he submits for the degree must be of A or B grade. Uncompleted work may be recorded by a deferred grade (Df); but such work, except that of thesis research, must be completed no later than the end of the next semester in which the student is registered.

Petitions. The normal procedures and requirements of the Graduate College are indicated in this catalog, but these may be modified occasionally for justifiable reasons. A student may petition to the Dean of the Graduate College for exceptions, but he should do so only after consultation with his adviser and with the recommendation of the department. Forms may be secured through the Department of Civil Engineering office.

Residence. Each degree candidate must spend a specified period of time in residence. The residence requirement is satisfied when a student lives in the community, or its immediate surroundings, and devotes an appreciable fraction of his time to graduate studies. A student who is regularly employed outside the Champaign-Urbana community is not considered to be in residence even though he is registered in a campus course.

Multiple Degrees. No more than two graduate degrees will be conferred for work completed at the University of Illinois. This means that a student intending to obtain a doctorate should not enroll for a master's degree in more than one department.

Military Service Classification. Students subject to military service may request the University to inform local draft boards of their graduate student status and request consideration for student classification.

THE DEGREE OF MASTER OF SCIENCE

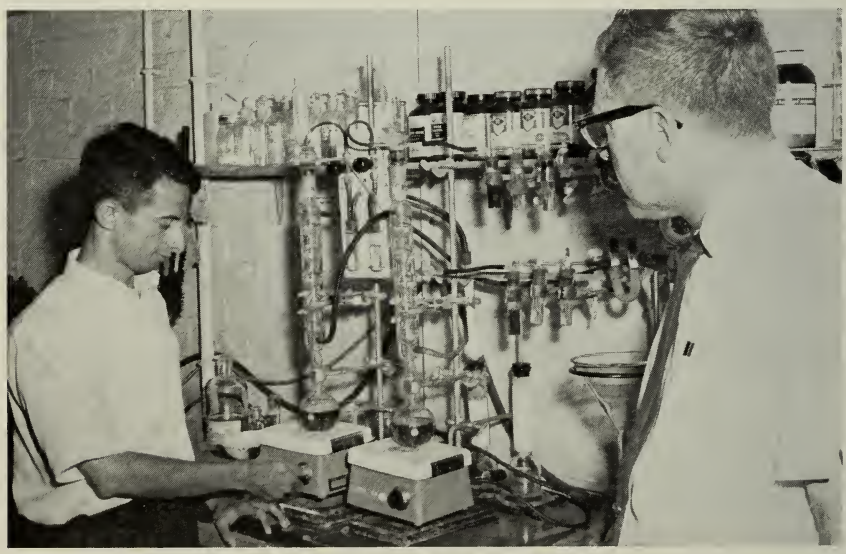
The degree of Master of Science is offered in the fields of civil engineering and sanitary engineering.

Credit Requirements. A candidate for the master's degree must complete at least eight units of graduate work with satisfactory grades. Three

of the eight units must be in courses numbered in the 400 series, and two of these three must be in the major field. A total of at least four units must be in the major field. When a thesis is not elected or required, the candidate must present at least nine units of course work.

Residence Requirements. A candidate for the master's degree must spend at least two semesters in residence and must earn at least half of the required units while in residence. Attendance during four summer sessions in each of which the student is registered for not less than one unit of work, or in one semester with not less than two units and two summer sessions with not less than one unit each, is regarded as the equivalent of two semesters in residence. Registration for more than two units in a regular semester, or for more than one unit in a summer session, does not shorten the time which must be spent to discharge the residence requirement.

Majors and Minors. A candidate for a master's degree may do all his work in one field, or he may select a major and one minor, or a major and two minors. A major or minor denotes the field of knowledge of a department, or such part thereof as constitutes a separate and independent division of that field. For a master's degree a major comprises work totaling a minimum of four units. Less than one unit of work does not satisfy the requirements for a minor.



Professor T. H. Thornburn advises Mr. K. Habibagahi, a graduate student, on his research in which the amount of organic carbon in a soil can be related to the engineering properties of the soil.

Foreign Language. During the first year of graduate study a student who plans to become a candidate for the Doctor of Philosophy degree should qualify in at least one of the languages required by the Graduate College.

Thesis. If a student elects to prepare a master's thesis or is required to do so by the department, he should file the subject of the thesis at the Graduate College office at least six weeks prior to graduation. No more than three units of thesis credit may be included in an eight-unit program. Credit in thesis research can not be applied to a degree unless a thesis is submitted. For specific instructions with reference to the preparation and form of the thesis, the student should obtain at the Graduate College office a copy of the leaflet "Instructions for Preparation of Theses."

Thesis Work on Leave of Absence. A student who has completed six units of course work in residence and who wishes to complete the thesis *in absentia* should consult first with his adviser. If the request meets with the latter's approval, a petition is submitted. The petition must include an outline of the proposed investigation and evidence that adequate facilities for pursuing it are available. If the work is to be done in an industrial laboratory, it is necessary to secure a letter from the company releasing to the University all patent and publication rights.

Suggested Programs. Suggested programs in the various fields in civil and sanitary engineering begin on page 63.

Conferring of Degrees. The master's degree is conferred in February, June, August, and October.

Not later than one week before the degree is conferred, each candidate for an advanced degree must obtain and complete a clearance paper from the Graduate College.

THE DEGREE OF DOCTOR OF PHILOSOPHY

The degree of Doctor of Philosophy, primarily a research degree, is offered in the fields of civil engineering and sanitary engineering.

Residence Requirements. A doctoral program includes three stages of progress. At least two of these stages must be completed in residence,

and the period in residence must include two successive semesters in the second or the third stage.

The first stage is completed when the candidate has received a master's degree or has earned the equivalent number of credits. The second stage consists of completion of a minimum of eight units of work, fulfillment of the major and minor course requirements, the language requirements (if not completed earlier), and a successful preliminary examination. The third stage is devoted to research and seminars with a minimum of eight units of credit, preparation of the dissertation, and the final examination.

It is possible to complete these three stages in three years if the student devotes full time to his academic program. For information concerning the maximum time allowed, see page 16.

Majors and Minors. A candidate is required to declare a major field of study and one minor (requiring at least four units) or two minors (requiring at least two units each). The requirements for a minor in any field should be checked with the department concerned.

Language Requirements. A candidate for the degree of Doctor of Philosophy must demonstrate a reading proficiency in two languages other than English, or a high degree of proficiency in one language other than English. Although French, German, and Russian are acceptable in all doctoral programs, candidates may be permitted in some cases to substitute other languages. A candidate should qualify in at least one of the required foreign languages during the first year of study. The entire language requirement should be satisfied early in the doctoral program and in any event no later than two months before the preliminary examination or during the semester (or summer session) preceding admission to the preliminary examination.

Students may satisfy reading proficiency by direct examination or by obtaining grades of A or B in French, German, or Russian 401. A student who wishes to satisfy the language requirement by a high proficiency in one language must pass a written-reading proficiency examination and must: (1) show ability to discuss his research and to answer questions in the language; (2) understand and give a resume of what the examiner reads to him from material in his field; (3) carry on a conversation on the subject of his background and plans. Certification of proficiency in foreign languages from other colleges and universities is not accepted by transfer.

Preliminary Examination. A candidate for the doctor's degree must pass a preliminary written (in most areas) and oral examination to test his knowledge of his major and minor fields of study. He is not admitted to the examination before: (1) he has fulfilled the language requirement; (2) he has satisfactorily completed at least sixteen units of graduate work; (3) the staff of his major and minor fields of study consider that he has adequate preparation.

Final Examination. After the credit requirements for the third stage and the thesis have been completed, the candidate is admitted to the final examination upon recommendation of the major department. A student who has failed to maintain high standards of scholarship and research is refused admission to the final examination. Although the examination is concerned primarily with the research accomplished by the student as described in his thesis, it may extend over the candidate's whole field of study.

Latest dates for final examinations of candidates for degrees in February, June, and October are shown in the Graduate College calendar.

Thesis. The degree of Doctor of Philosophy is primarily a research degree and consequently the candidate must demonstrate his capacity for independent research by preparing an original thesis on a topic within his major field of study. The subject of the thesis must be reported to the doctoral committee and to the Graduate College at the time of the preliminary examination. After passing this examination, the candidate *must* register each term (summer sessions excluded) until he receives his degree. When the credit requirement is satisfied (eight units of thesis research subsequent to passing the preliminary examination) the student maintains his status as a candidate by registering for zero credit in Thesis Research (C.E. 499).

Directions regarding thesis form and style are given in the leaflet "Instructions for Preparation of Theses," copies of which may be obtained in the Graduate College office. The candidate must submit to the Graduate College, no later than the date specified in the current calendar, (1) the original and first carbon (or two copies reproduced by an approved method) of his thesis and (2) one typewritten copy of an abstract of not more than six hundred words. In addition, two copies must be presented to the major department and one copy should be retained by the author.

Each candidate who passes the final examination must pay a $25.00 microfilm fee. This provides for microfilming of the complete thesis, with one copy deposited in the University of Illinois Library, and publication of the abstract in *Dissertation Abstracts.*

Conferring of Degrees. The doctor's degree is conferred in February, June, and October. Not later than one week before the degree is to be conferred, each candidate for an advanced degree must obtain and complete a clearance paper from the Graduate College office.

FINANCIAL ASSISTANCE

Various types of financial assistance are available each year to promising graduate students. Detailed information about the qualifications and application procedures for these awards is given in the brochure "Financial Aid for Graduate Students." This brochure, application form, and instructions will be furnished upon request to the Graduate College or the department. Only one University application form is needed to apply for any or all of the types of financial aid offered by the University. This one form may be used for fellowships, traineeships, teaching fellowships, assistantships (teaching or research), and tuition and fee waivers. To be considered for a fellowship, research assistantship, or tuition and fee waiver for the following academic year beginning in September, the application and *all* supporting material must be returned to the Head, Department of Civil Engineering, by February 15. Although applications for tuition and fee waivers and assistantships are accepted after that date for any additional openings that may possibly become available, applicants for such appointments are strongly urged to submit their applications as early as possible since most awards are offered at the same time that applications for fellowships are considered.

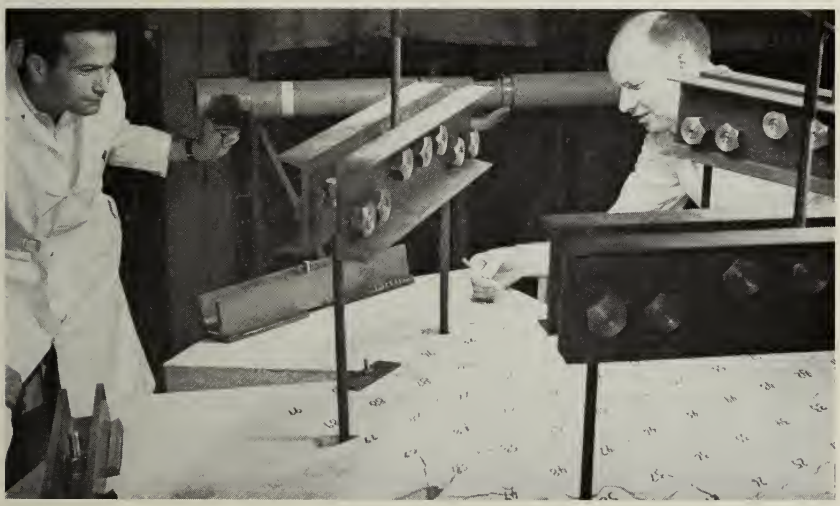
Applicants for financial aid whose native language is not English should submit their application material by November 1 or earlier in order to allow time for the University to arrange for the English language examination as explained under Admission. All financial stipends granted by the University of Illinois (as well as admission) require certification as to the English proficiency of the student.

Although it is not a requirement, students are advised that it is to their

advantage to take the Graduate Record Examination, and specifically the Aptitude Test (Quantitative and Verbal), and the Advanced Engineering Examination, and have the results forwarded to the Department of Civil Engineering at the University of Illinois. Information as to when and where the Graduate Record Examination is given (generally administered world-wide) may be obtained by writing directly to the Educational Testing Service at Princeton University, P.O. Box 955, Princeton, New Jersey 08540, U.S.A.

Also required of prospective civil engineering graduate students seeking financial support is a statement of rank in class and rank in college. Mimeographed forms for this purpose are available and are sent with application material. One form is to be filled out and returned by the applicant; the other one is to be filled out and returned by the appropriate school official.

The University of Illinois directly administers five main types of financial aid for graduate students. These are: (1) fellowships (including traineeships), (2) teaching fellowships, (3) assistantships, both in teaching and research, (4) tuition and fee waivers, and (5) loans.



Professor M. A. Sozen and Mr. R. Lenschow examine a circular reinforced concrete plate, with wings, after it has been subjected to bending and twisting moments. In the structures laboratory, a photogrammetry stereoscopic camera and mechanical dial gages are used to measure the deflections on this plate.

Fellowships and Traineeships

Fellowship stipends are gratuities awarded in recognition of scholarly achievement and promise and are intended to enable a student to pursue his graduate studies and research without requiring him to render any services. The stipends of different fellowships vary, but with few exceptions they are currently not less than $1,800 for the nine-month academic year, or $2,250 for the academic year plus the preceding or following summer session. The fellow's stipend is legally regarded as a gift, not as compensation for services rendered, and is therefore exempt from income tax. Unless explicitly stated otherwise, all fellows whose appointments are administered by the Graduate College are exempt from tuition and fees. A fellow is required to pursue a full program of graduate study (at least four units per semester) and may not engage in remunerative employment without the permission of the Dean of the Graduate College.

A traineeship is virtually equivalent to a fellowship since the stipend is considered a tax-free gratuity and no duties are required other than those directly contributing to the training program. The stipends vary, depending on the recipient's level of study and area of specialization. Tuition and fees are also ordinarily covered.

Selection of Fellows. Fellows are selected by the Graduate Fellowship Committee on the basis of scholarship and promise in teaching or research. All applicants are informed of the disposition of their applications on or about April 1. Successful applicants are expected to accept or decline by April 15. (See Acceptance Agreement, page 30.)

Departmental Requirement for Fellows. The department requires that all students holding fellowships or traineeships be engaged in some form of active research, either in association with one of the department's formal research programs, or on a special research program with his adviser. All students holding a first-year fellowship or traineeship must arrange to write a master's thesis (C.E. 499), or take at least one unit of Special Problems (C.E. 497), involving a comprehensive report on an individual investigation. This phase of the program provides the student with valuable training and serves as a guide to the department in making decisions about continuing studies and stipends. Second- and third-year fellows necessarily will be involved in research (and should be enrolled for credit accordingly) as a part of their doctoral study.

University Fellowships. University Fellowships are awarded on the basis

of an all-University competition and are unrestricted as to the student's field of graduate study. The recipient may choose either a nine-month or an eleven-month tenure. When tenure is for the regular academic year, the fellowship carries a stipend of not less than $1,800 plus exemption from the tuition and fees. On the eleven-month basis (academic year plus the preceding or following summer session), the stipend is not less than $2,250 plus exemptions.

Under certain conditions, University Fellows may engage in a limited amount of teaching, not to exceed one-quarter time. University Fellows normally carry a full program of four units, or the equivalent.

A number of summer fellowships that carry stipends of $450 with the usual exemption from tuition and fees are awarded to teaching assistants. These fellowships are restricted to graduate students who have held teaching assistantships at the University of Illinois for at least half-time for both semesters of the preceding academic year, who have earned not less than two units nor more than six units of graduate credit during that year.

Industrial, Endowed, and Special Fellowships. Various industrial firms, foundations, and private individuals have generously donated funds to support a number of special fellowships for graduate students. The stipends and supplemental allowances of these fellowships are not uniform. These fellowships include Automotive Safety Foundation Fellowship in Highway Engineering and Raymond International, Inc., Fellowship in Memorial to A. E. Cummings in Civil Engineering.

National Science Foundation Traineeships. Under this program, grants are made directly to the participating institutions, who select a specific number of promising individuals for full-time graduate study. Appointments may be made only to citizens of the United States (or native residents of a United States possession) who are enrolled in the graduate program. Trainees must devote full time to programs leading to advanced degrees, and may be appointed for nine- or twelve-month tenure only.

The basic stipend is $2,400 for those at first-year level, $2,600 for those at intermediate-year level, and $2,800 for those at terminal-year level. The Foundation also provides $500 per year for a dependent spouse and each dependent child. For nine-month awards, the allowance will be prorated. Under certain conditions, National Science Foundation Trainees can engage in a limited amount of teaching.

National Defense Graduate Fellowships. The University of Illinois Graduate College has a number of National Defense Graduate Fellowships which are financed under Title IV of the National Defense Education Act of 1958 and administered with the cooperation of participating departments. The purpose of the National Defense Graduate Fellowship program is to assist students who are preparing to teach in the nation's colleges and universities. Each fellowship, restricted to citizens or permanent residents of the United States, is for a three-year period to a student beginning his graduate studies. The current stipend for the academic year is $2,000 for the first year, $2,200 for the second, and $2,400 for the third, plus an additional allowance of $400 per year for each dependent. National Defense Graduate Fellowships carry the usual exemption from tuition and fees. Under certain conditions, National Defense Graduate Fellows may engage in a limited amount of teaching.

National Aeronautics and Space Administration Traineeships. The National Aeronautics and Space Administration (NASA) sponsors a number of traineeships for students who are majoring in the space-related sciences and technology. Awards are made to first-year graduate students and provide an annual tax-free stipend of $2,400 for twelve months, with exemption from tuition and all regular fees that are assessed at the time of registration. An allowance of up to $1,000 is provided for dependents. Given satisfactory progress, the traineeship is renewable, with escalated stipends, for a total of three years. NASA trainees must carry a full program — four units or the equivalent.

United States Public Health Service Traineeships. United States citizens pursuing a graduate degree in public health are eligible for Environmental Health Traineeships. Candidates for master's degrees can receive $3,000 per year, plus $500 annually for each dependent, from the United States Public Health Service through the Department of Civil Engineering. These traineeships include payment of tuition, fees, and a travel allowance to the campus.

Federal Water Pollution Control Traineeships. Through a grant to the University which is administered by the department, graduate students working in the area of water quality control are eligible for these traineeships if they are United States citizens. Stipends provide $3,000 per year for master's candidates and $3,600 per year for doctoral candidates, plus an annual allowance of $360 for each dependent and exemption from tuition and fees. Stipends are paid at a monthly rate for each actual month of training.

Tuition and Fee Waivers

These awards, available in limited number, provide exemption from tuition and all fees except the hospital-medical-surgical insurance fee for the academic year and the following summer session. Students holding these awards must be in residence and must register for at least three units each semester during the academic year. They may, however, accept part-time or incidental employment not to exceed twenty hours a week either within or outside the University.

A research fellow, Mr. M. W. Hall, in the sanitary engineering laboratory, is conducting a study on the removal of phosphorous from waste water by the activated sludge process.

Assistantships

Research Assistantships in the Engineering Experiment Station. The Engineering Experiment Station is devoted to the study of problems of special importance to engineering and to the stimulation and elevation of engineering education. By undertaking a program of graduate study in close association with some one of the projects carried on in the station, the student comes into contact with aspects of his specialty which he would rarely touch in a purely academic study, and thus broadens his outlook.

Half-time research assistantships, with a stipend of at least $2,700 for an academic year of two semesters, are open to graduates of approved technical colleges and universities. Applicants to whom these assistantships are awarded devote one-half of their time to the work of the Engineering Experiment Station and one-half to graduate studies. Each appointment is made for one academic year and normally is extended to permit the requirements for the master's degree to be satisfied. In general, with a half-time assistantship, two academic years of residence are required in order to obtain the master's degree. Half-time or full-time work at a comparable rate for two and one-half months is usually available during the summer months. Thus, with an academic year half-time and a summer full-time appointment, an assistant's annual stipend during the first year can be $4,200, plus exemption from tuition and fees during the academic year, but not the summer, if employed full time. Generally a commitment for a summer appointment can not be made in advance of the spring term preceding the summer session. A limited number of appointments are available, with prior arrangement, that permit completion of work for the master's degree by attending two consecutive summer sessions and the two regular semesters between them, or alternatively in three regular semesters.

Appointments to research assistantships are made only to students with outstanding records. Appointments are given to first-year and second-year graduate students, but only rarely to third-year students who have not previously studied at Illinois. Study toward the degree of Doctor of Philosophy also may be pursued by research assistants who have already received a master's degree and who satisfy the requirements of the department and the Graduate College.

Students holding academic appointments requiring service for more than 67 per cent time are required to pay tuition and fees. Thus those assis-

tants holding full-time appointments during the summer must pay fees. Those whose appointments call for a lesser percentage of time receive exemption from tuition and all fees except the hospital-medical-surgical insurance fee. Assistants must carry a reduced program of study, as shown on page 16.

A number of research assistantships in civil engineering and sanitary engineering are available. These include assistantships established by the University, and others provided by cooperative research agreements with state and federal agencies, technical societies, and engineering associations. Two half-time University research assistantships designated as the Terzaghi Assistantships are reserved for students primarily interested in soil mechanics.

Fields of research now active include all the programs shown in the introduction. Most programs have both experimental and analytical phases, and often both aspects are combined in order to permit broader training. It is usually possible to assign a research assistant to a project in the field of his special interest.

A thesis or research report is required at the master's level for all research assistants. Often the research in which he is engaged forms the basis of his thesis, but his thesis is not restricted to this field. Research assistants generally should register for special problems or thesis research during their first semester in order to gain additional experience in their area of research.

Applications for research assistantships should be made to the Head of the Department of Civil Engineering preferably not later than February 15 to be considered for appointments effective the following September. Applications received after this date are considered for any vacancies that may still exist. Although most appointments are made for the academic year beginning in September, some appointments may also be available in February or June.

Teaching Assistantships. In general, the department does not grant teaching assistantships to new graduate students. The normal procedure is to select teaching assistants from the research assistants who have served at least one semester in that capacity. Prospective graduate students who are interested in teaching should apply for a regular research assistantship and subsequently make their desires known to their adviser and to the head of the department.

Other Financial Aids

A number of other sources of support are available, for example, fellowships offered by the American Society of Civil Engineers, the American Institute of Steel Construction, and other organizations. Students are encouraged to apply for such stipends.

Acceptance Agreement

The University of Illinois adheres to the following resolution adopted by the members of the Association of American Universities and a number of other graduate schools of North America:

"In every case in which a graduate assistantship, scholarship, or fellowship for the next academic year is offered to an actual or a prospective graduate student, the student, if he indicates his acceptance before April 15, will still have complete freedom through April 15 to reconsider his acceptance and to accept another fellowship, scholarship, or graduate assistantship. He has committed himself, however, not to resign an appointment after this date unless he is formally released from it."

Loan Funds

University loan funds have been established for the benefit of worthy students who need financial assistance. The University of Illinois also participates in the Student Loan Program under the National Defense Education Act. Application forms and additional information on loans may be secured from the Dean of Students' Office, 346 Student Services Building, Champaign, Illinois 61820.

FEES AND EXPENSES

Tuition and other fees, as indicated below, are payable in full when the student registers, unless the installment plan of payment is elected. An additional charge of $2.00 is made for this privilege.

Tuition and Fees

(As of September, 1966)

Semester

	Full Program		*Partial Programs*			
	Range I		Range II		Range III	
	Above 10 hours Above 2½ units		Above 5 to 10 hours Above 1¼ to 2½ units		Above 0 to 5 hours Above 0 to 1¼ units	
	Resident	Non-resident	Resident	Non-resident	Resident	Non-resident
Tuition (except those holding exemptions)	$ 85.00	$375.00	$60.00	$265.00	$35.00	$155.00
Service Fee[1]	40.00	40.00	25.00	25.00	10.00	10.00
Hospital-Medical-Surgical Insurance Fee[2]	10.00	10.00	10.00	10.00	10.00	10.00
Total	$135.00	$425.00	$95.00	$300.00	$55.00	$175.00

Eight-Week Summer Session

	Full Program		*Partial Programs*			
	Range I		Range II		Range III	
	Above 5 hours Above 1¼ units		Above 2½ to 5 hours Above ¾ to 1¼ units		Above 0 to 2½ hours Above 0 to ¾ unit	
	Resident	Non-resident	Resident	Non-resident	Resident	Non-resident
Tuition (except those holding exemptions)	$ 45.00	$190.00	$30.00	$130.00	$20.00	$ 80.00
Service Fee[1]	20.00	20.00	15.00	15.00	5.00	5.00
Hospital-Medical-Surgical Insurance Fee[2,3]	10.00	10.00	10.00	10.00	10.00	10.00
Total	$ 75.00	$220.00	$55.00	$155.00	$35.00	$ 95.00

[1] Persons on appointment for at least 25 per cent of full time on the academic, administrative, or permanent nonacademic staff of the University, or on the staffs of allied agencies, and persons registering *in absentia* or in courses conducted off-campus are exempt from the service fee.

[2] Students presenting evidence of equivalent coverage may receive a waiver of this fee upon approval of a petition submitted to the University Insurance Office not later than the final day established for full refund of fees. A signed waiver and assumption of responsibility is required. Persons registered for thesis research *in absentia* are not assessed this fee.

[3] If insurance coverage for the period between the close of the summer session and the beginning of the first semester is not desired, $5.00 will be refunded if requested in writing prior to the final date established for full refund of fees.

Noncredit Courses

Students who register in noncredit courses pay tuition and fees as follows:

(1) Persons (except those holding exemptions) who register *on campus* for doctoral thesis research (Civil Engineering 499) only, without credit, are charged the following:

Semester and Eight-Week Summer Session

	Semester	*Summer Session*
Tuition	$10.00	$10.00
Service Fee	10.00	5.00
Hospital-Medical-Surgical Insurance Fee	10.00	10.00

(2) Persons who register for doctoral thesis research (Civil Engineering 499) *in absentia* without credit are charged only a tuition fee of. .$10.00

(Those registered *in absentia* for credit pay the regular tuition, resident or nonresident, as applicable.)

(3) Persons who register in noncredit seminars, either alone or in addition to other courses. . . . . *No charge*

(Regular tuition and fees which are applicable are assessed for other courses taken concurrently.)

(4) Persons not holding tuition waivers who register for less than a full program of credit courses (Range II or III) pay for each noncredit course. $15.00

(This is in addition to the required tuition and fees for credit courses.) If taken alone noncredit courses other than thesis research and seminar are assigned to Range III.

Off-Campus Courses (field courses)

Students pay the regular tuition and Hospital-Medical-Surgical Insurance fees. They are exempt from the service fee.

Residence Classification

The residence classification of an applicant is determined on the basis of information given on his application and other credentials. Fees are assessed in accordance with this decision. If the student believes he has a legitimate cause for change of status, he may, by petition, on a form provided by the Office of Admissions and Records, request a change. Peti-

tions are considered *within thirty days* from the date designated in the official University Calendar as that upon which instruction begins for the academic period for which the fee is payable.

Further information concerning residency may be secured by contacting the Director of Admissions and Records, 100a Administration Building, Urbana, Illinois 61801. A brochure entitled *Regulations Governing Assessment of Resident or Nonresident Student Fees* is also available.

Special Fees

Following is a partial list of special fees pertaining to graduate students. A complete schedule of tuition and fees may be obtained from the Office of Admissions and Records, 100a Administration Building.

Late Registration Fine — $15.00. All students, whether on appointment or not, who complete registration for courses on campus after the close of the regular registration, are subject to this fine in addition to the tuition and fees. A student's registration is not complete until his tuition and fees have been paid in full, or he has made arrangements with the Bursar's Office for deferment of payment. Students who register late in any term pay the same tuition and fees as students who register at the beginning of the term.

Change of Program Fee — $1.00. This fee is charged for every course change slip issued at the request of the student after the completion of registration.

The behavior of a reinforced micro-concrete folded plate roof model is studied by Mr. V. C. Corsetti, whose studies are being sponsored by the National Science Foundation.

Vehicle Registration — $5.00 per year for a motor vehicle and $3.00 per year for a motorcycle, motor scooter, or motor bicycle. All resident students enrolled in the Graduate College who have these motor vehicles in their possession are required to register them with the Motor Vehicle Division. Bicycles also must be registered with this division. No fee is charged for such registration.

Visitor's Fee — $15.00. Persons not otherwise registered in University courses and students registered on campus on a partial program fee schedule (Range II or III), except those holding scholarships, tuition waivers, or staff appointments, which exempt them from tuition for campus work unless such scholarships are specifically limited are charged this fee for each course attended as a visitor only.

Transcript Fee — $1.00. Each student who has paid all his University fees is entitled to receive, without charge, one transcript of his record. For each additional transcript this fee is charged.

Refund of Fees

A student subject to tuition and/or fees who withdraws from the University during any term may receive refunds. See the Graduate College catalog for details.

HOUSING

The University has residence facilities in Arthur Hill Daniels Hall and Stuart Pratt Sherman Hall, two separate residence hall complexes for approximately 1,000 single graduate students, both men and women. In one unit, Daniels Hall, contract food service in an undergraduate dining hall located directly across the street can also be arranged. In addition, the University provides a limited number of apartments for married students, with priority in assignment given to part-time research and teaching assistants.

Applications for accommodations in the University graduate residence halls or the University-owned apartments for married students may be obtained from the Housing Division, 420 Student Services Building, Champaign, Illinois 61820. The Housing Division also maintains a courtesy list of private apartments and rooms available in homes in the community.

BUILDINGS AND EQUIPMENT

New Civil Engineering Building. Teaching and research activities of the department have been conducted in several different locations on the Urbana campus. The future holds much promise for improved facilities with the completion of various portions of the new civil engineering building.

Phase IA of the Civil Engineering Building contains a test floor 47 by 85 feet for use by graduate students and those conducting research. In this area are large machines for determining the fatigue strength of full-size structural members and the strength of members subjected to rapidly applied loads. Extensive hydraulic loading facilities are important features of this laboratory. The laboratory contains electronic data reduction equipment, metallurgical laboratory, machine shop, and welding shop. These extensive facilities are also available in Talbot Laboratory to study the fundamental behavior of structures and structural components of wood, steel, and other metals, reinforced concrete, and prestressed con-

Dr. N. M. Newmark (right) discusses the civil engineering building program with Professor G. K. Sinnamon (left) and Professor R. J. Mosborg beside the model of the buildings to be on the main campus.

crete, and for the study of dynamic behavior of structures as influenced by various forms of excitation, including vibration, impact, earthquakes, and blast. The *concrete laboratory* in the Civil Engineering Building is equipped for the study of the physical properties of concrete as influenced by proportioning, mixing, placing, curing, and environment. A large batch plant provides accurate and convenient service during research.

The *soil mechanics laboratory* is among the most complete in the world. Equipment for the performance of consolidation of pressures, and model tests for investigating a variety of soil-structure interaction problems, is available. Special equipment is available for tests in rock mechanics, and for chemical and rheological studies of soils.

The *airphoto interpretation laboratory* contains modern optical equipment for examining various kinds of aerial imagery. Included are stereoscopes, ranging from the simple pocket type, through mirror and scanning types, to the latest zoom type. The latter permits stereo viewing at continuously variable in-focus magnifications from 2.5 to 20 times. For the preparation of engineering maps, a vertical reflecting projector and a topographic plotter coupled to a mirror stereoscope are available. For high precision mapping, more refined photogrammetric equipment is available in the *photogrammetric engineering laboratory,* with which close liaison is maintained. Training in the evaluation of terrain for engi-

First portion of the new Civil Engineering Building, nearing completion.

neering purposes is greatly facilitated by a collection of several thousand photographs, stereograms, geologic maps, and soils maps representing landform areas throughout the world.

The *sanitary engineering laboratories* occupy more than 15,000 square feet of space in the new building. The laboratories are equipped with modern precision instruments for the physical, biological, radiological, and chemical investigation of water, waste water, and air. In addition, spectrophotometers, Warburg respirometers, radiation counting equipment, a refrigerated high-speed centrifuge, a liquid scintillation counter, walk-in constant temperature rooms, and a recording polarograph are available for use. Students have access to electron microscope, radiocarbon, and infrared analysis laboratory apparatus. Pilot plant facilities for water and waste treatment are used for instructional and research purposes.

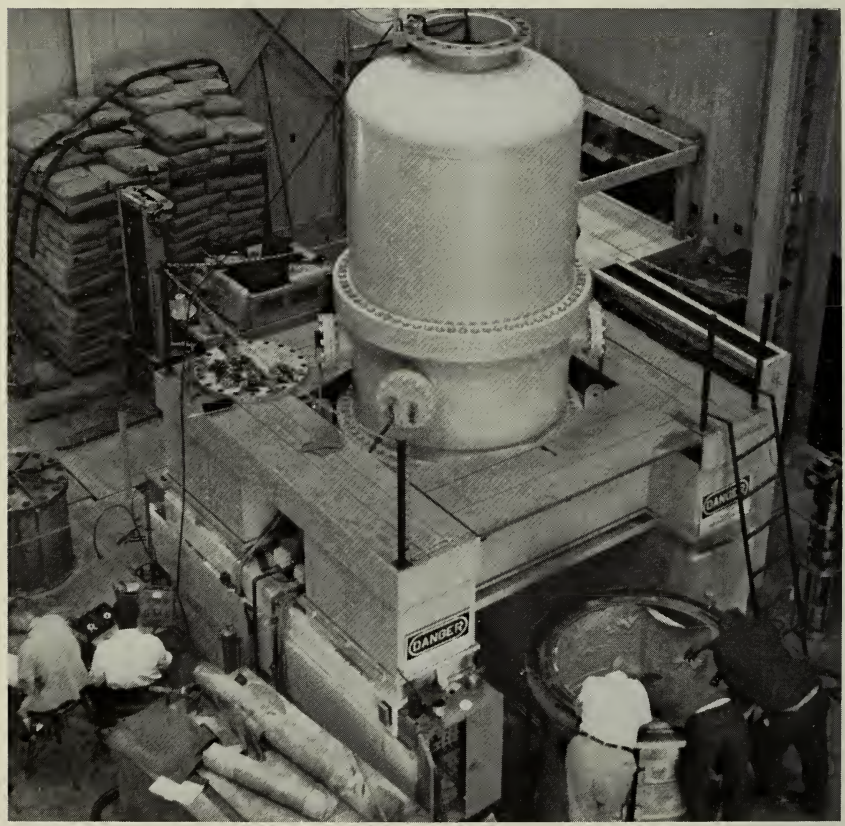
Research in water treatment, treatment of domestic, industrial, and waste waters, air pollution control, and other aspects of sanitary engineering are being carried on in the laboratories. Opportunities to participate in the established projects and to pursue research independently on selected topics are offered.

Phase IB, the *Structural Dynamics Laboratory,* is a special facility for dynamic tests at high pressures involving soil structure interaction and re-

The Structural Dynamics Laboratory, in operation south of the main campus.

lated aspects of dynamic loading. Pulse loading pressures (three milliseconds or longer), ranging up to 800 pounds per square inch, can be applied in a test tank that is 4 feet in diameter and 8 feet deep. Because of the type of tests being conducted in this laboratory, it is remotely located south of the main campus.

The *Hydraulic Engineering Laboratory* has a main laboratory pumping system composed of five pumps with a combined capacity of 5,000 gallons per minute at a head of about forty-five feet. Water storage and sump facilities, with a capacity in excess of 22,000 gallons, supply the water



This equipment in the new Structural Dynamics Laboratory can apply a pulse loading pressure ranging up to 800 pounds per square inch over a four-foot diameter surface with a time of application of three milliseconds or longer. In addition, it has a capability of sustained steady loading of indefinite duration, and a controlled pressure decay in times as short as ten to fifteen milliseconds.

recirculation system. Piping arrangements are designed to permit simultaneous constant head and high rate flows without interference. A separate laboratory, containing its own pump, water supply, circulation system, and measuring apparatus, is maintained for the use of graduate students.

Instrumentation in the *Hydraulic Engineering Laboratory* is of the latest type. One channel area is 10 feet wide and 330 feet long, and it is equipped with a traveling crane for the handling of heavy equipment. This space is well adapted to studies relating to either open channel or pipe flow. Another area, 40 by 40 feet, is a watershed facility that can be controlled with computers for storms up to ten inches of rainfall per hour. Available within the laboratory are complete shop facilities for the construction of research installations and models, including apparatus for molding plastic materials.

Graduate students in civil engineering often elect courses which make use of the Department of Theoretical and Applied Mechanics laboratories located in Talbot Laboratory. The facilities include a *hydraulics laboratory*, which is equipped with a standpipe, pumps, weirs, orifice tanks, turbines, long concrete channels, and other facilities for instruction and research in hydraulics; the *applied mechanics laboratory*, equipped with standard and special testing machines of various types and capacities; and the *fatigue of metals laboratory*, equipped with a variety of machines for testing metals under fatigue loading. The *highway materials laboratories* are equipped for tests and research in bituminous materials and mixes, as well as in stabilized soils, soil-aggregate mixtures, and other nonbituminous highway materials.

Engineering Hall. This building presently houses the department office, offices of members of the staff, classrooms, a graduate study room, a student lounge, the Engineering Library, the College of Engineering administrative offices, and some offices of the Institute of Aviation.

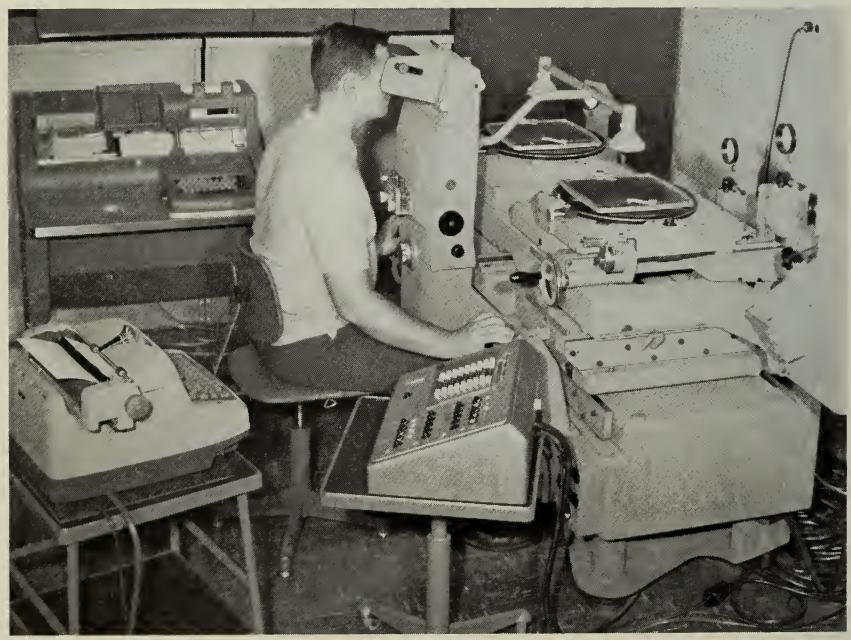
Located in Engineering Hall are the facilities for the Construction Engineering and Management Programs. Scientific methods for conceptualizing, analyzing, planning, and controlling of construction operations are being developed. The group makes extensive use of the IBM 1620 computer system in the *civil engineering systems laboratory.*

The *traffic engineering laboratory* for teaching and research is located in this building. The laboratory contains a traffic signal demonstration panel which can be operated individually or collectively with all types of signal

controllers, radar speedmeters, traffic counters, a twenty-pen recorder, a traffic operations model, volume or density computer, and other technical equipment; including a research vehicle.

Photogrammetric and Geodetic Engineering Laboratories. These laboratories include an extensive collection of modern instruments which are used for advanced instruction and research in photogrammetric and geodetic engineering. For instruction in precise control surveying including geodetic astronomy, modern equipment includes first-order Wild N-3 level and Wild T-2 theodolite with prismatic astrolable attachment. For advanced instruction and research in photogrammetry the following new equipment is available: Wild STK-1 Stereocomparator and Wild A-9 Super-Wide-Angle Autograph, and Ziess SMK-40 Stereometric camera.

Pavement Materials and Behavior Laboratory. Extensive facilities are available for evaluating paving materials and for studying the behavior of pavements under static and repeated dynamic loads. The pavement study area is being rebuilt near the northeast corner of the campus and consists of three single-story buildings plus outside area for storage and handling of materials.



In the photogrammetric laboratory, a Wild STK-1 Stereocomparator is used to make measurements to the nearest micron (0.00025 inch) of the photo coordinates of image points by students and faculty.

Materials Research Laboratory. This building contains new facilities for conducting the standard tests on paving materials, plus many pieces of special equipment designed at the University of Illinois. Facilities are available for handling and processing the large quantities of materials needed in the test pavements, including a mixer for blending concrete and stabilized paving materials, a small but complete hot-mix plant, compaction tools, and special equipment for pulverizing the soil and adjusting the water content.

The pavement behavior test area contains a test track in which either static or repeated dynamic loads can be applied to model pavements. Static loads up to 80,000 pounds can be applied to the test pavements as well as repeated wheel loads in excess of 3,000 pounds. The wheel loads can be applied at a rate of more than a quarter-million load applications per week. The pavement test area contains equipment for adjusting the water table below the test pavements and for control of the temperature and humidity of the atmosphere immediately above the test pavements.

Library Facilities. The University of Illinois Library ranks first among state universities in its size, and the resources for advanced study and research are outstanding. Its present collections now exceed 3,889,000 volumes, all but about 294,000 of them located in Urbana.

In addition to the figures for cataloged volumes cited, the University Library contains approximately 525,000 pamphlets, 298,900 maps and aerial photographs, and 295,000 music scores and parts. More than 20,000 periodicals and newspapers are currently recieved.

The Library's bibliographical facilities comprise a general catalog of more than 5,000,000 cards, a union catalog of titles owned by about two dozen major American and foreign libraries; printed catalogs of libraries, e.g., the Bibliothèque Nationale, British Museum, and Library of Congress; national and trade bibliographies of all countries for which such works have been issued; bibliographies of special subjects; and similar aids.

Outstanding collections have been developed in the science-technology fields. The Engineering, Physics, Mathematics, Chemistry, and Geology libraries are located conveniently to the College of Engineering. Their combined collections include more than 4,380 journal titles and 191,640 books. Graduate students have free access to all library bookstacks. Microreproduction and photo duplication facilities, interlibrary loan service from other institutions for those engaged in research for dissertations, individual reference service, and assistance in using the collections, catalogs, and indexes are also available.

Computational Aids. Available for civil engineering research are a number of computational aids for use in various studies of numerical methods, for the numerical solution of stress analysis problems, instability, vibration, impact, heat flow, etc., and for data reduction and processing. For advanced study and research, the department has an IBM 1620 computer system located in Engineering Hall in support of the Construction Engineering and Management programs, and other disciplines.

The Department of Computer Science, located in the Digital Computer Laboratory, has available computing facilities for student use. An IBM 7094-1401 computing system is available for general University use in research and instruction. The department has recently constructed a very high-speed computer of its own design (Illiac II). At present this computer is being augmented with a flexible complement of input-output equipment including the possibility of remote consoles. Extensive program libraries are available for both the Illiac and the IBM systems. In addition to general programs, many special purpose programs developed by civil engineering staff and graduate students are available for the static and dynamic analysis and design of a variety of complex structures, for data reduction, for traffic and equipment allocation studies, for train performance simulation, for planning construction operations, and for many other research problems. Students interested in gaining programming experience may take the non-credit course, Computer Science 400. All the computing facilities are used extensively in analytical and design-oriented research programs in civil engineering. They make possible investigations involving complex computations which are impracticable or even impossible by other means and greatly expand the scope of both the analytical and design-oriented, as well as some phases of experimental research.

COURSES IN CIVIL ENGINEERING AND SANITARY ENGINEERING

The prerequisite for graduate work in civil engineering and sanitary engineering is the equivalent of the undergraduate courses required for the degree of Bachelor of Science in the branch of the subject in which registration is desired.

Courses numbered from 300 to 399 are open to advanced undergraduate and graduate students. Those numbered 400 and above are open to graduate students only.

301. Advanced Surveying. Precise horizontal and vertical control surveys; state plane coordinate systems; special construction surveys. ½ unit. Prerequisite: Civil Engineering 202 or consent of instructor.

302. Photogrammetric Engineering. A study of metrical photography in civil engineering practice; characteristics and interpretation of aerial and terrestrial photographs; stereoscopic compilation of maps from photographs; mosaics; economics of photogrammetry; map reproduction. ½ unit. Prerequisite: Civil Engineering 202 or consent of instructor.

305. Observational Astronomy. Same as Astronomy 314. Astronomical coordinate systems and transformations; theory of, and practice in, approximate and precise determinations of latitude, longitude, and time; introduction to theory of errors; theory and practice of astronomical photography. 1 unit. Prerequisite: Astronomy 102 or 210; Mathematics 142 or 143.

314. Fundamentals of Systems Approach. Introduction to the application of linear programming, network theory, and queueing theory to the synthesis of civil engineering systems. ½ or 1 unit. Prerequisite: Civil Engineering 215; Mathematics 263 or consent of instructor.

315. Construction Productivity. Introduction to the application of scientific principles to the measurement of and the forecasting of productivity in construction engineering; conceptual and mathematical formulations of the labor, equipment, and material factors affecting productivity. ½ or 1 unit. Prerequisite: Civil Engineering 215; credit or registration in Mathematics 263 or equivalent; or consent of instructor.

316. Construction Planning. Introduction to the application of scientific principles to the normative planning of construction operations. ½ or 1 unit. Prerequisite: Civil Engineering 315 or consent of instructor.

318. Construction Cost Analyses and Estimates. Introduction to the application of scientific principles to costs and estimates of costs in construction engineering; concepts of and statistical measurements of the factors involved in direct costs, general overhead costs, cost mark-ups and profits; the fundamentals of cost recording for construction cost accounts and cost controls. ½ or 1 unit. Prerequisite: Civil Engineering 315 or consent of instructor.

321. Bituminous Materials and Mix Design. Properties and control testing of bituminous materials; analysis of bituminous paving mixtures; composition and design of asphaltic concrete and soil-asphalt mixes. ½ unit. Prerequisite: Civil Engineering 214 and 220, or consent of instructor.

322. Development of Highway Facilities. Analysis of factors in developing a highway transportation facility; traffic estimates and assignment; problems of highway geometrics and design standards; planning and location principles; intersection design factors; street systems and terminal facilities; programming improvements; drainage design; structural design of surface; concepts of highway management and finance; highway maintenance planning. 1 unit. Prerequisite: Civil Engineering 220 or consent of instructor.

325. Highway Traffic Characteristics. Vehicle operating characteristics; driver characteristics; pedestrian characteristics; roadway characteristics as they indi-

vidually, and collectively as traffic stream characteristics, are related to the planning, design, and operation of highway facilities. ½ unit. Prerequisite: Civil Engineering 220 or consent of instructor.

333. Urban and Regional Transportation. Importance of transportation and its relation to urban and regional planning; problems of demand; characteristics of transport systems; transportation planning including surveys, data analysis, and problems of administration and finance; coordination and integration of transport. ½ or 1 unit. Prerequisite: Consent of instructor.

334. Airport Design. Basic principles of site selection for airports and fundamental considerations of design, construction, and maintenance of airport pavements and structures. ½ or 1 unit. Prerequisite: Civil Engineering 220 and senior standing in civil engineering, or consent of instructor.

335. Railway Construction and Maintenance. Loads and load distribution on track and subgrade; roadbed construction and stabilization; track stresses, design, and materials; turnouts and crossings; maintenance programs. ½ or 1 unit. Prerequisite: Consent of instructor; credit or registration in Civil Engineering 230 for those with a minor in railroad or transportation engineering.

336. Railway Location and Operation. Influence of traffic, alignment, distance, gradients, and motive power upon operating expenses; mechanics of train operation; economic design of location. ½ or 1 unit. Prerequisite: Consent of instructor; credit or registration in Civil Engineering 230 for those with a minor in railroad or transportation engineering.

337. Signals. Train movements; systems of signals; track circuits; track capacity; interlockings; economics of signaling. ½ or 1 unit. Prerequisite: Consent of instructor; credit or registration in Civil Engineering 230 for those with a minor in railroad or transportation engineering.

338. Terminals. Design and operation of freight terminal facilities for rail, highway, air, and water carriers; passenger terminals and parking lots; terminal requirements for commodity categories; coordination. ½ or 1 unit. Prerequisite: Consent of instructor; credit or registration in Civil Engineering 230 for those with a minor in railroad or transportation engineering.

345. Environmental Health Engineering. The application of engineering principles to the control of environmental sanitation and communicable disease control, including administration, biostatistics, epidemiology, vector control, pesticides, milk and food sanitation, swimming pools, individual water supply and wastewater disposal, plumbing, refuse collection and disposal, industrial hygiene and air pollution, radiological health and international health. ¾ unit. Prerequisite: Consent of instructor.

346. Biology of Polluted Water. The significance of biology in water quality, stream pollution, and waste treatment. ½ unit. Prerequisite: Consent of instructor.

349. Fundamentals of Radiation Protection. Same as Nuclear Engineering 349. Principles and practice of health physics and radiation protection engineering, including such topics as: principles of dosimetry; sources of ionizing radiation; determination of radiation tolerances; dosimetric instruments; standards and

regulations. ¾ or 1 unit. Prerequisite: Nuclear Engineering 397 or Physics 382, or equivalent.

351. Hydromechanics. Applied fluid mechanics with particular reference to topics in hydraulic design, analysis, and research in civil engineering areas; covers dimensional analysis and dynamic similarity, analysis of potential flow, boundary-layer problems, turbulence and diffusion. Hydraulic transients, water waves, transport phenomena. ¾ unit. Prerequisite: Theoretical and Applied Mechanics 235; Civil Engineering 251.

352. Water Resources Design. Study and evaluation of phases of river mechanics; water resources history and project implementation; development of a water resources project plan. ¾ unit. Prerequisite: Civil Engineering 250; Theoretical and Applied Mechanics 235.

353. Hydraulic Structures. Introduction to the design of hydraulic structures, including consideration of types and function of dams; hydrologic design; hydraulic design of spillways and outlet works; determination of loads and stresses for concrete structures; seepage, piping, and stability of earth structures. ¾ unit. Prerequisite: Civil Engineering 250 and 251.

354. Hydraulic Engineering Laboratory. Fundamental principles, operation, and use of model laboratories; dimensional analysis; hydraulic similitude; theory and design of hydraulic models as applied to a specific laboratory problem. ¾ unit. Prerequisite: Theoretical and Applied Mechanics 235.

361. Advanced Structural Analysis. Numerical methods of structural analysis; general theory of continuity; prismatic and nonprismatic members; continuous framed structures; trussed structures; lateral load distribution; secondary stresses. ¾ or 1 unit. Prerequisite: Civil Engineering 262 or equivalent.

A watershed experimentation system has been developed under the direction of Professor V. T. Chow (standing) and is in operation in the Hydraulic Engineering Laboratory. Mr. T. E. Harbaugh is seated. The system includes the use of an electronic computer to control rainfall intensities, as well as move a "laboratory storm" across the watershed model which measures 40 by 40 feet.

363. Behavior and Design of Metal Structures, II. Members under combined loads; welded, riveted, and bolted connections; moment-resistance connections; plastic design. ¾ or 1 unit. Prerequisite: Civil Engineering 263 or consent of instructor.

364. Reinforced Concrete Design, II. Limit design of continuous reinforced concrete members and slabs of various types. ¾ or 1 unit. Prerequisite: Civil Engineering 264; credit or registration in Civil Engineering 262.

366. Behavior of Reinforced Concrete Members. Ultimate strength and behavior of reinforced concrete members and relation between results of research and current specifications for design; members subjected to flexure, axial compression, combined flexure and axial load, combined flexure and shear, and bond. 1 unit. Prerequisite: Bachelor of Science in civil engineering or architecture with courses in structures and reinforced concrete design.

368. Prestressed Concrete. Principles and methods of linear prestressing; behavior, strength, and design of noncomposite simple beams, composite simple beams, and continuous beams; time-dependent variables and long-time deflections. ¾ or 1 unit. Prerequisite: Civil Engineering 262 and 264.

369. Behavior and Design of Wood Structures. Theory and practice in design of modern wood structures; effect of plant origin and physical structure of wood on its mechanical strength; fasteners and their significance in design and the development of design formulae. ¾ or 1 unit. Prerequisite: Civil Engineering 261 or equivalent, or consent of instructor.

380. Foundation Engineering. Evaluation of subsoil conditions as they affect the behavior, proportions, and choice of type of foundations; bearing capacity and settlement analyses; character of natural soil deposits; earth pressure theories and retaining wall analysis; slope stability. 1 unit. Prerequisite: Civil Engineering 210.

383. Soil Mechanics. Identification, description, and classification of soils; index properties, weight-volume relationships; hydraulic properties; stress-deformation characteristics; ultimate strength; subsurface exploration; character of natural soil deposits. ¾ or 1 unit. Prerequisite: Consent of instructor.

384. Applied Soil Mechanics. Application of soil mechanics to foundations of buildings; stability of earth slopes; earth pressure and retaining walls; braced cuts; damage due to construction operations. ¾ or 1 unit. Prerequisite: Civil Engineering 383 or consent of instructor.

385. Engineering Aspects of Surficial Soils. Use of geologic and pedologic information and airphoto interpretation techniques in the prediction of engineering properties of soils and the planning of engineering soil surveys. Field trip; estimated expense, $5.00. 1 unit. Prerequisite: Civil Engineering 210 or consent of instructor.

391. Computer Methods in Civil Engineering. Review of programming concepts; formulation and programming of numerical, data-processing, and logical problems with applications from various branches of civil engineering; organization of programs and data; development and use of problem-oriented programming languages in civil engineering. ½ or 1 unit. Prerequisite: Mathematics 195 or Computer Science 400, or equivalent.

Courses for Graduates

403. Photogrammetry. Study of the principles of stereoscopy and geometrical optics; aerial cameras, their design and calibration; the design, construction, and operation of stereoscopic plotting machines; mathematics of stereoscopic orientation and model deformations. 1 unit. Prerequisite: Civil Engineering 302 or consent of instructor. KARARA.

404. Photogrammetry. Theory of errors of stereoscopic photogrammetry; aerotriangulation (spatial and radial), its theory and applications to various civil engineering problems; electronics in photogrammetry; practice in compiling maps from aerial and terrestrial photographs. 1 unit. Prerequisite: Civil Engineering 302 or consent of instructor. KARARA.

416. Design of Construction and Industrial Operations, I. Same as Industrial Engineering 416. Conceptual development of a systems design procedure for optimal design of construction and industrial operations; general forms required for critical path networks, linear programs, theory of queues and inventory models required for systems design; design evaluation and control models. 1 unit. Prerequisite: Bachelor of Science in civil or industrial engineering; credit or registration in Mathematics 363; or consent of instructor. SHAFFER.

417. Design of Construction and Industrial Operations, II. Same as Industrial Engineering 417. Continuation of Civil Engineering 416. 1 unit. Prerequisite: Civil Engineering or Industrial Engineering 416; credit or registration in Mathematics 315; or consent of instructor. SHAFFER.

In the traffic engineering laboratory, characteristics of traffic flow are obtained by using modern electronic equipment to make continuous recordings. Mr. F. L. Greenawalt, a research assistant (right), compares recent recordings with Mr. R. H. Wortman, an instructor.

420. Pavement Design, I. Analysis and methods of measurement of surface properties related to vehicle performance; factors affecting pavement durability; traffic wear, climate, chemical action, combined effects; composition design of flexible and rigid pavements for proper surface properties, load carrying capacity, wear resistance, stability, and durability. 1 unit. Prerequisite: Civil Engineering 220 or equivalent. DANNER.

421. Pavement Design, II. Structural design of flexible and rigid pavements; loading characteristics, static, impact and repeated loads; load distribution through pavement layers, factors affecting distribution, methods of analysis; evaluation of subgrade support; criteria for selecting design values. 1 unit. Prerequisite: Civil Engineering 220 or equivalent. HERRIN.

426. Traffic Planning. Traffic engineering planning functions; urban and rural master traffic plans; traffic analyses for new or existing streets, highways, and terminal facilities. 1 unit. Prerequisite: Civil Engineering 325 or equivalent. BAERWALD.

427. Geometric Highway Design. Highway classification; highway capacity; highway design controls; sight distance; horizontal and vertical alignment; cross section elements; highway types; controlled access highways; design of at-grade intersections, grade separations, and interchanges. 1 unit. Prerequisite: Civil Engineering 325 and 426, or consent of instructor. BAERWALD.

428. Traffic Engineering Operations. Theory of traffic control; laws and ordinances; design and application of traffic control devices; special street designations; parking design and control; street illumination; miscellaneous traffic control designs. 1 unit. Prerequisite: Civil Engineering 325 and 426, or equivalent. BAERWALD.

435. Railway Construction and Maintenance. Roadbed load capacity; track stresses; economic design of track; economics of maintenance; review of specific projects. 1 unit. Prerequisite: Civil Engineering 335. HAY.

436. Railroad Location and Operation. Track and traffic capacity; optimum train size, performance, and scheduling train performance simulation and analysis; optimum size of plant and modern location. 1 unit. Prerequisite: Civil Engineering 336 or consent of instructor. HAY.

440. Theory of Water Treatment. Properties of water and criteria of water quality; gas transfer operations in water treatment; chemical treatment processes; corrosion and corrosion control; sedimentation; filtration; disinfection; control of aquatic growths; control of tastes and odors. 1 unit. Prerequisite: Chemistry 122 and Microbiology 101. DICK, O'CONNOR.

441. Analysis and Treatment of Water and Waste Water. Physical, biological, and chemical analysis of water and waste water; field sampling techniques; removal of objectionable impurities, principles of disinfection; determination of dissolved oxygen, biochemical oxygen demand, and chemical oxygen demand; nitrogen, sulfur, and phosphorous compounds in waste waters. 1 unit. Prerequisite: Credit or registration in Civil Engineering 440. AUSTIN, O'CONNOR.

442. Theory of Waste-Water Treatment. Composition, properties, and analysis of wastes; microbiology of waste treatment; pollution of natural waters; sedi-

mentation; chemical treatment; aerobic and anaerobic treatment processes; disposal of waste sludges. 1 unit. Prerequisite: Civil Engineering 346; Chemistry 122; Microbiology 101. Austin, Engelbrecht.

443. Advanced Sanitary Engineering Laboratory. Experimental and pilot plant studies of the operational characteristics for various physical, chemical, and biological unit operations and processes used in the treatment of water and waste water. 1 unit. Prerequisite: Civil Engineering 441; credit or registration in Civil Engineering 442. Dick, O'Connor.

444. Industrial Water and Wastes Treatment. The theory and application of unit operations unique to the treatment of industrial water and wastes; advanced consideration of industrial waste problems of major industries; techniques of saline water conversions. 1 unit. Prerequisite: Credit or registration in Civil Engineering 440 and 442, or consent of instructor. Engelbrecht, O'Connor.

445. Water Quality and Pollution. Water quality standards and criteria for various beneficial uses; transport mechanisms for pollution in surface streams and ground water; fate of pollution and pollution control. 1 unit. Prerequisite: Civil Engineering 250 and 251; Mathematics 345. Dick, Ewing.

446. Design of Water and Waste Treatment Plants. A study of the fundamental factors affecting choice of treatment units and combination of unit processes into an integrated plant. 1 unit. Prerequisite: Civil Engineering 440, credit or registration in Civil Engineering 442, or consent of instructor. Dick, Ewing.

447. Radioactive Waste Disposal. Same as Nuclear Engineering 447. Sources and characteristics of radioactive wastes; methods of treatment; ultimate disposal; fate of radioisotopes in the environment; permissible levels in air and water; current levels in water supplies; water treatment methods; monitoring techniques; solid waste disposal; gaseous wastes disposal; air monitoring; and reactor site selection and hazards evaluation. ½ or 1 unit. Prerequisite: Physics 282, or Chemistry 398 or Nuclear Engineering 398, or consent of instructor. Austin, Ewing.

448. Control of Air Pollution. A study of air contaminants from all types of sources; deleterious effects of contaminants on plants, animals, and materials; determination of source strength; basic theory of control devices; air pollution surveys; and organization of control programs. 1 unit. Prerequisite: General Engineering 360. Austin, Pearson.

449. Analysis of Air Pollutants. Laboratory analysis of common air pollutants; theory of operation of laboratory and automatic field instrumentation. ½ or 1 unit. Prerequisite: Credit or registration in Civil Engineering 448. Austin, Pearson.

450. Advanced Hydrologic Analysis and Design. Hydrologic cycle; hydrometeorology; collection of data; hyetograph and hydrograph analyses; infiltration and evapotranspiration studies; groundwater exploration and recharge; statistical analyses; determination of waterway areas; flood routings; river and reservoir regulations; design and planning of flood control projects; and modern development such as radar weather, radioactive tracers, disposal of nuclear wastes, and electronic analogs. 1 unit. Prerequisite: Bachelor of Science in civil engineering or consent of instructor. Chow.

452. Water Resources. An advanced interdisciplinary course on water resources planning and development; geographic aspects; data collection; governmental functions; hydrologic implications; river hydraulics; hydraulic physical units and water quality; economic aspects; legal, political, and social problems; case studies. 1 unit. Prerequisite: Consent of instructor. CHOW, STAFF.

456. Hydraulics of Surface Drainage. Applications of hydraulics and hydrologic principles; elements of channel design, hydrologic determination of design flow, hydraulics of culverts and bridge openings, overland flow, flow in gutters and inlets, and hydrologic and hydraulic design of a bridge opening or culvert system. 1 unit. Prerequisite: Theoretical and Applied Mechanics 235. STAFF.

457. Ground Water. An advanced interdisciplinary course on ground water; hydrogeology; hydrodynamics of flow through porous media; ground water hydrology; hydraulics of wells; hydraulic analysis of seepage; ground water pollution; ground water resources. 1 unit. Prerequisite: Consent of instructor. CHOW, STAFF.

458. Open-Channel Hydraulics. Basic hydromechanics; flow types; channel characteristics; flow-profile computations; hydraulic jump analysis; design of nonerodible, erodible, and gassed channels and transitional structures; study of supercritical flow and unsteady flow; modern developments in theory and design practice; application of numerical method, method of characteristics, method of singular point, and electronic digital computers and analogs. 1 unit. Prerequisite: Bachelor of Science in civil engineering or consent of instructor. CHOW.

461. Structural Theory and Design. Advanced structural theory from the standpoint of design, analysis, and behavior, with particular emphasis on analysis; evaluation of methods of elastic analysis of structures; limit design and analysis; continuous beams and frames; multiple-story structures; space frames; arches. 1 unit. Prerequisite: Bachelor of Science in civil engineering; Civil Engineering 361 or equivalent. FENVES, HALL, STALLMEYER.

462. Structural Theory and Design. Statically indeterminate trusses; continuous trusses; steel arches; secondary stresses; suspension bridges; long span roofs. 1 unit. Prerequisite: Bachelor of Science in civil engineering; Civil Engineering 361 or equivalent. MOSBORG, STALLMEYER.

465. Structural Design in Metals. Theories of behavior of structural metal members and their components; interpretation of codes and specifications for the design of bridges and buildings. This course and Civil Engineering 475 form a unit in the study of theoretical and experimental investigations. 1 unit. Prerequisite: Bachelor of Science in engineering with courses in structures. GAYLORD.

467. Behavior of Reinforced Concrete Structures. Ultimate strength and behavior of statically indeterminate reinforced concrete structures; applicability of elastic analysis to framed structures; analysis and design of floor slabs in buildings. 1 unit. Prerequisite: Civil Engineering 366. SIESS.

470. Statistical Theory of Structural Engineering. Study of the concepts and applications of probability and statistical theory in structural engineering and research, with emphasis on the scientific principles for considering fluctuations

and randomness in physical phenomena and processes; mathematical modeling in structural mechanics including Monte Carlo simulation in structural systems analysis and design; engineering decision-making under uncertainty; analysis of loads and resistances; safety analysis of structures including system reliability prediction; introduction to stochastic structural dynamics. 1 unit. Prerequisite: Consent of instructor. ANG.

471. Numerical and Approximate Methods of Structural Analysis. Methods of successive approximations and numerical procedures for the solution of complex problems with applications to bridges, buildings, and aircraft structures: influence lines, moments and deflections of beams with axial load, buckling strength of columns, moments and deflections of beams resting on elastic or plastic supports, vibration of beams, analysis of arches, moments and deflections of plates, other problems. 1 to 2 units. EUBANKS, MELIN, ROBINSON.

472. Advanced Numerical Methods in Engineering. Basic concepts in numerical and approximate methods: successive approximations, relaxation, finite differences, ordinary boundary value problems, initial value problems, partial differential equations, characteristic value problems, methods of interpolation, variational procedures. Special study of selected topics including vibrations of complex structures; blast, impact, and earthquake effects on structures; buckling and flexure of frameworks; torsion of solid and thinwalled sections; lateral buckling of beams; bending and buckling of plates and of stiffened plates; plane stress and axially symmetric problems in elasticity; other topics. 1 to 2 units. Prerequisite: Civil Engineering 471. EUBANKS, ROBINSON.

473. Analysis and Design of Plates and Shells. Fundamental theories of bending and buckling of plates; practical application of theories in analysis and design of reinforced concrete bridge and building floors, highways and airport pavements, and structural plate components in metal; theory of shells with application to tanks, pressure vessels, shell roofs, and hipped plate construction. 1 to 2 units. Prerequisite: Consent of instructor. SCHNOBRICH.

474. Behavior of Structures Under Dynamic Loads. Free vibrations, forced vibration, and transient response of structures and structural components having one or many degrees of freedom; analytical methods for the effects of wind load, explosion blast, impact, earth tremors, and other time-dependent excitations; effects of damping and inelastic action; propagation of stress waves; wind-induced vibrations with application to cables, pipelines, and tall stacks. 1 to 2 units. Prerequisite: Consent of instructor. WALKER.

475. Behavior of Steel Structures. A critical evaluation of the actual behavior of metals, connections, members, and structures; the significance of this behavior in terms of design and the development of design specifications. This course and Civil Engineering 465 form a unit in the study of theoretical and experimental investigations. 1 unit. Prerequisite: Graduate standing in civil engineering or theoretical and applied mechanics. MUNSE.

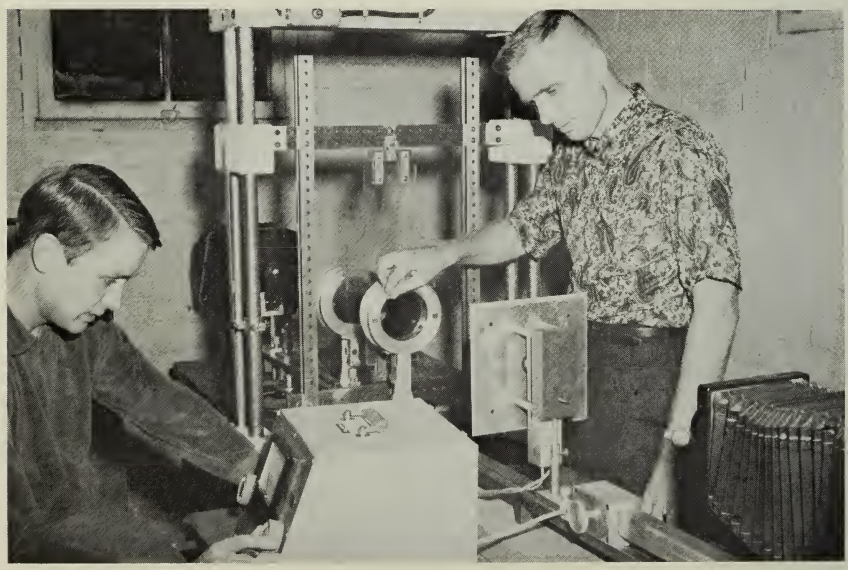
476. Plastic Analysis and Design. Inelastic behavior of metal structural frameworks; concept of the plastic hinge; collapse configurations; analysis of collapse mechanisms; requirements for stability; deflections, incremental collapse, shakedown; connections; optimum design; grid frameworks. 1 unit. Prerequisite: Civil Engineering 465 or consent of instructor. GAYLORD.

477. Design of Structures for Dynamic Loads. Nature of dynamic loading from earthquakes and bomb blasts; nature of dynamic resistance of structural elements and complete structures; concepts of limit design; review of methods of analysis; significance and interpretation of results of analyses; criteria for design of blast-resistant structures; criteria for design of earthquake-resistant structures; application to actual problems. 1 unit. Prerequisite: Consent of instructor. HALTIWANGER, NEWMARK.

478. Matrix Theory of Structural Mechanics. Fundamental concepts of matrix calculus and its applications for a unified treatment of advanced structural mechanics and dynamics; basic calculus of matrices; iterative solution of systems of algebraic and differential equations; stress and structural analysis, method of tearing tensors; discrete simulation of continuous systems in higher dimensions; eigen-value problems of discrete systems. 1 unit. Prerequisite: Civil Engineering 461 or 471, or consent of instructor. ANG.

479. Applied Structural Mechanics. Study of beams under lateral load; beams with combined lateral load and thrust; buckling; beams on elastic foundations; applications of Fourier series and virtual work principles to beam-type structures; stress and strain in three dimensions; applications to flexure of beams and plates and to constrained torsion; elements of the engineering theory of plates. 1 unit. Prerequisite: Mathematics 345 and one undergraduate course in statically indeterminate structures, or consent of instructor. PAUL, ROBINSON.

480. Earth Pressures and Retaining Structures. Classical and modern earth pressure theories and their experimental justification; pressures and bases for



In one of the structures laboratories, Professor W. J. Hall (right) with Mr. H. Ottsen, a research assistant, adjusts the polariscope on a photoelastic loading frame used to measure the stress concentrations of models.

design of retaining walls, bracing of open cuts, anchored bulkheads, cofferdams, tunnels, and culverts. 1 unit. Prerequisite: Credit or registration in Civil Engineering 384. HORN, IRELAND, PECK.

481. Earth Dams and Related Problems. Fundamentals of problems of slope stability; seepage in composite sections and anisotropic materials; methods of stability analysis; mechanism of failure of natural and artificial slopes; compaction; field observations, 1 unit. Prerequisite: Credit or registration in Civil Engineering 384, or consent of instructor. PECK.

482. Measurement of Soil Properties. Laboratory and field work in soil sampling, classification, and testing; experimental studies of modern soil mechanics parameters and theories with emphasis on applications to design problems. Experiments include permeability, consolidation, direct shear, and triaxial shear. The research approach is used to point out interpretations and limitation of data in practice. 1 unit. Prerequisite: Credit or registration in Civil Engineering 383, or consent of instructor. OLSON.

483. Soil Mechanics. Advanced studies of research techniques in soil mechanics and foundation engineering. 1 unit. Prerequisite: Civil Engineering 384 or consent of instructor. OLSON.

484. Foundation Engineering. Critical study of case histories of projects in foundation engineering; current procedure for design and construction of foundations, embankments, and waterfront structures. 1 unit. Prerequisite: Civil Engineering 384. IRELAND, PECK.

485. Soil Engineering for Transportation Facilities. Problems of soil classification; evaluation of stability of natural and compacted soils as subgrades, slopes, and embankments; effect of climate, soil properties, compaction, and admixtures on subgrade stability. 1 unit. Prerequisite: Civil Engineering 383 or equivalent. LIU, THORNBURN.

492. Measurement Theory and Experimental Design. The principles of engineering experimentation from both a classical and a statistical point of view. Nature of experimental error; test planning; data analysis; special techniques. Examples within the civil engineering discipline are emphasized. 1 unit. Prerequisite: Mathematics 263 or equivalent. CHILTON.

494. Municipal Administration and Engineering. Legal authority of municipalities, forms of municipal government; municipal functions, organization, and management; city finance; engineering functions of city government; city planning and zoning; building codes and inspection; street lighting; public utilities; city cleaning; recreational development. 1 unit. Prerequisite: Bachelor of Science in civil engineering or consent of instructor. DANNER.

495. Civil and Sanitary Engineering Seminar. Discussion of current topics in civil and sanitary engineering and related fields by staff, students, and visiting lecturers. Course may be repeated. 0 or ¼ unit.

497. Special Problems. Individual investigations or studies of any phase of civil engineering selected by the student and approved by his adviser and the staff member who will supervise the investigation. 0 to 4 units. Prerequisite: Consent of instructor.

499. Thesis Research. 0 to 4 units.

Suggested Topics for Civil Engineering 497 (Special Problems)

Regular courses have been established to cover many phases of civil engineering. Even so, students may wish to take advantage of Civil Engineering 497 for special studies. In most areas, extensive use is made of Civil Engineering 497 to cover subjects not now included in the regular courses. Examples of possible topics include:

CIVIL ENGINEERING SYSTEMS

Computer-Aided Design . . . Network Modeling of Engineering Systems . . . Data Processing Systems . . . Optimization and Synthesis . . . Problem-Oriented Languages.

CONSTRUCTION ENGINEERING AND MANAGEMENT

Construction Productivity Measurement . . . Network Theory Based on Construction Planning . . . Computer-Based Accounting and Estimating . . . Computer-Based Management Systems . . . Operations Research in Construction Management.

HYDRAULIC ENGINEERING

Water Waves and Coastal Engineering . . . Watershed Hydraulics and Urban Hydrology . . . Sedimentation in Rivers and Reservoirs . . . Operations Research in Water Resources Planning and Development . . . Stochastic Hydrology.

PHOTOGRAMMETRIC AND GEODETIC ENGINEERING

Analytical Photogrammetry . . . Terrestrial Photogrammetry . . . Close-Range Photogrammetry . . . Theory of Measurements . . . Adjustment of Observations . . . Electronic Distance Measurements.

PLAIN CONCRETE

Nature of the Constituent Materials of Concrete . . . Quality Control and Specifications . . . Durability of Concrete . . . Creep and Relaxation of Concrete . . . Fatigue and Fracture of Concrete.

SANITARY ENGINEERING

Stream Pollution . . . Water Quality Aspects of Water Resources . . . Air Pollution . . . Radiological Health . . . Chemical, Physical, and Biological Aspects of Water Supply and Pollution Control.

SOIL AND ROCK MECHANICS

Soil and Rock Dynamics . . . Soil-Structure Interaction Problems . . .

Physicochemical Properties of Soils . . . Soil Stabilization . . . Fundamentals of Rock Mechanics . . . Quantitative Terrain Analysis.

STRUCTURAL ENGINEERING

Structural Mechanics . . . Probability and Stochastic Processes . . . Structural Theory: Instability, Limit Analysis, Matrix, and Network Methods . . . Structural Dynamics . . . Shell Structures . . . Prestressed and Reinforced Concrete Structures . . . Riveted, Bolted, and Welded Joints . . . Fatigue and Fracture of Metal Structures.

TRANSPORTATION

Planning, Systems Design, and Operations. Design of Transport Systems . . . Environmental Factors in Transportation . . . Technological Development of Transport Media . . . Waterways, Airways, and Pipelines.

Materials and Structural Design of Roadways. Properties and Performances of Aggregates . . . Properties of Bituminous Materials and Mixes . . . Pavement Analysis and Behavior . . . Soil and Material Stabilization.

Highway Traffic Engineering. Organization and Management . . . Traffic Records and Accident Analyses . . . Maintenance and Operations . . . Analyses of Traffic Problems . . . Roadway Location and Design . . . Traffic Flow Theory.

Railway Engineering. Stresses in Track . . . Track and Roadway Structures . . . Problems in Railway Management . . . Train Performance Simulation and Analysis.

SELECTED COURSES OFFERED IN OTHER DEPARTMENTS[1]

Agronomy

440. Design and Analysis of Biological Experiments, I. 1 unit. Prerequisite: Consent of instructor.

441. Design and Analysis of Biological Experiments, II. 1 unit. Prerequisite: Agronomy 440.

[1] Courses numbered in the 300 series are open to advanced undergraduates and graduate students and those numbered in the 400 series are open to graduate students only.

Chemistry

315. Inorganic Chemistry. ½ unit. Prerequisite: Credit or registration in Chemistry 315.

321. Chemical and Instrumental Analysis. ¾ to 1¼ units. Prerequisite: Chemistry 336 and 340 or 342 with registration in Chemistry 343 and 344.

322. Analytical Separations and Experimental Design. ¾ unit. Prerequisite: Chemistry 321 or equivalent.

336. Organic Chemistry. ¾ unit. Prerequisite: Chemistry 133 with a grade of A or B, or Chemistry 234.

340. Principles of Physical Chemistry. 1 unit. Prerequisite: Physics 102; Chemistry 122 and 133, or equivalent; Mathematics 132 or equivalent.

342. Physical Chemistry. This course and Chemistry 344 constitute a year-long study of chemical principles. Students who do not intend to take Chemistry 344 should not enroll in Chemistry 342. ¾ unit. Prerequisite: Chemistry 108, 122, 123, or equivalent; Physics 106, 107, and 108, or two semesters of general physics with concurrent registration in the third semester; credit or registration in Mathematics 142 or equivalent.

344. Physical Chemistry Laboratory. Continuation of Chemistry 342. ¾ unit. Prerequisite: Chemistry 342.

346. Physical Chemistry of Macromolecules. ¾ or 1 unit. Prerequisite: Chemistry 340 or 344, or consent of instructor.

350. General Biochemistry. ¾ unit. Prerequisite: Quantitative analytical chemistry, and Chemistry 133 or 234, or equivalent.

397. Radiochemistry. Same as Nuclear Engineering 397. ¾ unit. Prerequisite: One semester of physical chemistry or one semester of atomic physics or consent of instructor.

398. Radiochemistry Laboratory. Same as Nuclear Engineering 398. ½ unit. Prerequisite: One semester of physical chemistry or one semester of atomic physics or consent of instructor.

Computer Science

400. Introduction to Automatic Digital Computing for Graduate Students. No credit.

Economics

360. Regional Economic Development. ½ or 1 unit. Prerequisite: Economics 103 or 108.

374. Operations Research. ½ or 1 unit. Prerequisite: Economics 170 and Industrial Administration 101, or consent of instructor.

384. Economics of Transportation. ½ or 1 unit. Prerequisite: Economics 103 or 108.

386. Current Transportation Problems. ½ or 1 unit. Prerequisite: Economics 384.

400. General Economic Theory. 1 unit. Prerequisite: Economics 102, 103, or 108.

401. General Economic Theory. 1 unit. Prerequisite: Economics 103 or 108.

414. Public Finance. 1 unit. Prerequisite: Six hours of economics.

415. Economics of Taxation. 1 unit. Prerequisite: Six hours of economics.

440. Labor Economics. Same as Labor and Industrial Relation 440. 1 unit. Prerequisite: A minimum of six hours of economics.

470. Economic Statistics. 1 unit. Prerequisite: Consent of instructor.

474. Operations Research. 1 unit. Prerequisite: Mathematics 363 and Economics 374 or equivalent.

484. Economics of Transportation. 1 unit.

485. Economics of Transportation. 1 unit.

General Engineering

360. Engineering Applications of Meteorological Fundamentals. 1 unit. Prerequisite: Mathematics 142 or 143; Physics 106, 107, and 108; Mechanical Engineering 205 and 206, or 209, or Chemistry 342 and 344, or Physics 360.

Geography

313. Climates of the Continents. ¾ unit. Prerequisite: Geography 101 and 111.

365. Geography of Transportation. ¾ unit.

366. Location of Industry and Other Economic Activities: Theory and Practice. ¾ unit.

373. Map Compilation and Construction. 1 unit. Prerequisite: Consent of instructor.

378. Descriptive Interpretation of Remote Sensors. 1 unit. Prerequisite: Consent of instructor.

383. Urban Geography. 1 unit.

412. Analytical Climatology. 1 unit. Prerequisite: Geography 111; Geography 313 or equivalent; consent of instructor.

473. Problems in Cartography. 1 unit. Prerequisite: Georgraphy 373 or consent of instructor.

495. Advanced Studies in Geography. Directed and supervised detailed investigation of selected problems or regions. ½ to 2 units. Work may be taken in urban geography.

Geology

301. Geomorphology. 1 unit. Prerequisite: Geology 102.

450. Geology for Civil Engineers. 1 unit. Prerequisite: Geology 150 or equivalent.

455. Hydrogeology. 1 unit. Prerequisite: Consent of instructor.

461. Mineralogy of Clays. 1 unit. Prerequisite: Geology 366 or Chemistry 328, or equivalent.

462. Mineralogy of Clays. 1 unit. Prerequisite: Geology 461.

493. Advanced Studies in Geology. ½ to 2 units. Work may be taken in engineering geology.

Industrial Administration

401. Scientific Management — Qualitative. 1 unit.

402. Scientific Management — Quantitative. 1 unit.

Industrial Engineering

333. Engineering Applications of Statistics. ¾ or 1 unit. Prerequisite: Mathematics 263 or 363.

Mathematics

315. Linear Transformations and Matrices. 1 unit. Prerequisite: One year of calculus.

341. Differential Equations. 1 unit. Prerequisite: One year of calculus.

342. Differential Equations. 1 unit. Prerequisite: Mathematics 341.

343. Advanced Calculus. 1 unit. Prerequisite: One year of calculus.

345. Differential Equations and Orthogonal Functions. 1 unit. Prerequisite: One year of calculus.

346. Complex Variables and Application. 1 unit. Prerequisite: Mathematics 343 or consent of instructor.

361. Theory of Probability. 1 unit. Prerequisite: one year of calculus.

363. Advanced Statistics. 1 unit. Prerequisite: One year of calculus.

364. Advanced Statistics. 1 unit. Prerequisite: Mathematics 363.

381. Vector and Tensor Analysis. 1 unit. Prerequisite: Mathematics 343 or equivalent, or consent of instructor.

382. Vector, Tensor, and Matrix Methods in Applied Mathematics. 1 unit. Prerequisite: Mathematics 381 or consent of instructor.

386. Laplace Transforms. 1 unit. Prerequisite: Mathematics 343.

387. Introduction to Numerical Analysis. 1 unit. Prerequisite: Mathematics 195 and a course in differential equations, or consent of instructor.

388. Mathematical Methods in Engineering and Science. 1 unit. Prerequisite: Mathematics 343.

395. Programming, Languages and Computation. 1 unit. Prerequisite: Mathematics 195, 295, or consent of instructor.

397. Mathematical Theory of Data Processing. 1 unit. Prerequisite: Mathematics 195 or consent of instructor.

444. Partial Differential Equations. 1 unit. Prerequisite: Consent of instructor.

455. Mathematical Methods of Physics. 1 unit. Prerequisite: Mathematics 348.

457. Advanced Numerical Analysis. 1 unit. Prerequisite: Mathematics 387 or consent of instructor.

458. Numerical Solution of Partial Differential Equations. 1 unit. Prerequisite: Mathematics 455 or consent of instructor.

Microbiology

309. Cultivation and Properties of Microorganisms. 1 unit. Prerequisite: Organic chemistry, with biochemistry recommended; or consent of instructor.

326. Pathogenic Bacteriology. 1 unit. Prerequisite: Microbiology 101 or 201 or 309; organic chemistry.

330. Metabolic Regulation and Genetics of Microorganisms. ¾ unit. Prerequisite: Microbiology 101 or 201, or equivalent; credit or registration in biochemistry or consent of instructor; calculus strongly recommended.

351. Viruses. ¾ unit. Prerequisite: Organic chemistry; biochemistry recommended.

420. Chemistry of Microbic Processes. ¾ unit. Prerequisite: Microbiology 309 or 330 and Chemistry 234 and 350, or equivalent; consent of instructor.

Nuclear Engineering

347. Introduction to Nuclear Engineering. ¾ or 1 unit. Prerequisite: Physics 282 or 382 and senior standing in engineering, or consent of instructor.

349. Fundamentals of Radiation Protection. Same as Civil Engineering 349. ¾ or 1 unit. Prerequisite: Nuclear Engineering 397, or Physics 382, or equivalent.

397. Radiochemistry. Same as Chemistry 397. ¾ unit. Prerequisite: One semester of physical chemistry, or one semester of atomic physics, or consent of instructor.

398. Radiochemistry Laboratory. Same as Chemistry 398. ½ unit. Prerequisite:

One semester of physical chemistry, or one semester of atomic physics, or consent of instructor.

401. Fundamentals of Nuclear Engineering. 1 unit. Prerequisite: Physics 282 or 382 and Mathematics 345, or equivalent, or consent of instructor.

441. Nuclear Radiation Shielding. 1 unit. Prerequisite: Nuclear Engineering 347, Mathematics 343 and 345, or consent of instructor.

451. Reactor Laboratory. ½ or 1 unit. Prerequisite: Consent of instructor.

458. Nuclear Reactor Engineering. 1 unit. Prerequisite: Consent of instructor.

467. Thermomechanics of Nuclear Reactor Systems. 1 unit. Prerequisite: Nuclear Engineering 401 or consent of instructor.

Physics

321. Theoretical Mechanics. 1 unit. No credit for graduate physics majors. Prerequisite: General physics; registration in Mathematics 341, 345, or 349.

322. Theoretical Mechanics. Continuation of Physics 321. 1 unit. Prerequisite: Physics 321.

382. Nuclear Physics. 1 unit. Prerequisite: Physics 381 or 383.

383. Atomic Physics and Quantum Theory for Engineers. ¾ or 1 unit. Prerequisite: General physics; general chemistry; Mathematics 345 or equivalent.

Physiology

301. General Physiology. Same as Zoology 301. 1 unit. Prerequisite: One year each of college-level biology, mathematics, and physics; chemistry through organic.

331. General Radiobiology. 1 unit. Prerequisite: One year each of mathematics, physics, chemistry, and biology.

462. Experimental Bioclimatology. Same as Geography 462. ½ unit. Prerequisite: Physiology 301, or 401 and 402; credit or registration in Physiology 461.

Political Science

406. Municipal Administration. 1 unit.

Sociology

385. Social Statistics, I. 1 unit. Prerequisite: Sociology 185 or Mathematics 122 or 123, or consent of instructor.

476. Urban Communities and Urbanization. 1 unit.

Theoretical and Applied Mechanics

311. Mechanical Vibrations. ½ to 1 unit. Prerequisite: Theoretical and Applied Mechanics 154 or 156 or 211 or 212 and 221.

314. Advanced Dynamics for Engineers. 1 unit. Prerequisite: Theoretical and Applied Mechanics 211 or equivalent; Mathematics 341 or 345.

315. Advanced Dynamics with Applications to Engineering Problems. 1 unit. Prerequisite: Theoretical and Applied Mechanics 314 or equivalent.

321. Advanced Mechanics of Deformable Bodies. ½ or 1 unit. Prerequisite: Theoretical and Applied Mechanics 221 and 223 or 224.

324. Flow and Fracture of Structural Metals. ¾ unit. Prerequisite: Theoretical and Applied Mechanics 221 and 224, or consent of instructor.

326. Experimental Stress Analysis. ½ to 1 unit. Prerequisite: Theoretical and Applied Mechanics 150, 211, 212, 221, and 223 or 224. Theoretical and Applied Mechanics 321 is desirable.

334. Fluid Mechanics and Advanced Hydraulics. ½ to 1 unit. Prerequisite: Theoretical and Applied Mechanics 235.

335. Dynamics of Fluids. ¾ or 1 unit. Prerequisite: Theoretical and Applied Mechanics 235.

346. Dimensional Analysis and Theory of Models. ½ or 1 unit.

In the hydraulics laboratory, Professor H. G. Wenzel, Jr. (left) and a graduate student examine a light interrupter disk used in obtaining photomicrographs of the movement of small spheres suspended in water.

351. Advanced Mechanics of Continuous Media. 1 unit. Prerequisite: Theoretical and Applied Mechanics 221; Mathematics 343; a course in differential equations.

400. Seminar in Engineering Mechanics. ¼ unit.

412. Vibration Analysis. Continuation of Theoretical and Applied Mechanics 311. 1 unit. Prerequisite: Theoretical and Applied Mechanics 311.

416. Energy Principles in Engineering Mechanics. 1 unit. Prerequisite: Theoretical and Applied Mechanics 451.

424. Properties of Engineering Materials. ½ or 1 unit.

425. Mechanics of Inelastic Bodies. ½ to 1 unit. Prerequisite: Theoretical and Applied Mechanics 321.

426. Stress and Deformation in Engineering Components. Continuation of Theoretical and Applied Mechanics 321. ½ to 1 unit. Prerequisite: Theoretical and Applied Mechanics 321 or equivalent.

427. Theories of Mechanical Properties and Behavior of Plain Concrete. ½ to 1 unit. Prerequisite: Bachelor of Science degree in engineering.

428. Analysis of Nonlinear Systems. Same as Electrical Engineering 428. 1 unit. Prerequisite: Mathematics 341 and consent of instructor.

431. Theory of Ideal Fluid Flow. 1 unit. Prerequisite: An elementary course in fluid flow and a course in advanced calculus.

432. Theory of Flow of Viscous Fluids. Although a logical continuation of Theoretical and Applied Mechanics 431, this course need not be taken sequentially. 1 unit. Prerequisite: An elementary course in fluid flow and a course in differential equations.

438. Turbulence. 1 unit. Prerequisite: Theoretical and Applied Mechanics 432.

441. Applied Analysis in Engineering. 1 unit. Prerequisite: Mathematics 143; Mathematics 343 and 345 are recommended.

442. Applied Analysis in Engineering. Continuation of Theoretical and Applied Mechanics 441. 1 unit. Prerequisite: Mathematics 143; Mathematics 343 and 345 are recommended.

451. Theory of Elasticity with Application to Engineering Problems. 1 unit. Prerequisite: Mathematics 343; Mathematics 341 or equivalent.

452. Theory of Elasticity with Application to Engineering Problems. Continuation of Theoretical and Applied Mechanics 451. 1 unit. Prerequisite; Theoretical and Applied Mechanics 451.

454. Theory of Shells. 1 unit. Prerequisite: Theoretical and Applied Mechanics 451.

457. Classical Elastostatics. 1 unit. Prerequisite: Theoretical and Applied Mechanics 451 or equivalent; Consent of instructor.

458. Wave Motion in Continuous Media. 1 unit. Prerequisite: Theoretical and Applied Mechanics 311, 314, 451; Mathematics 341, 342, 343, or equivalent.

460. Continuum Mechanics. 1 unit. Prerequisite: Theoretical and Applied Mechanics 351 or equivalent.

462. Theory of Plasticity. ½ to 1 unit. Prerequisite: Theoretical and Applied Mechanics 451 or equivalent.

464. Theory of Buckling. ½ to 1 unit. Prerequisite: Theoretical and Applied Mechanics 416 and 451.

467. Thermomechanics of Nuclear Reactor Systems. Same as Nuclear Engineering 467. 1 unit. Prerequisite: Nuclear Engineering 401 or consent of instructor.

472. Advanced Photoelasticity. 1 unit. Prerequisite: Theoretical and Applied Mechanics 326 and 451, or consent of instructor.

Urban Planning

374. Urban Planning Theory. ½ unit. Prerequisite: Urban Planning 171 or consent of instructor.

376. Planning Analysis. ½ unit. Prerequisite: Urban Planning 171 or consent of instructor.

377. Comprehensive Planning Procedure. ½ unit. Prerequisite: Urban Planning 171.

380. Survey of Regional Planning. ½ unit. Prerequisite: Urban Planning 171 or consent of instructor.

488. Urban Planning Research. ½ to 2 units. Prerequisite: Urban Planning 171 or consent of instructor.

Zoology

304. Field and Systematic Zoology. 1 unit. Prerequisite: One year of zoology or equivalent.

343. Limnology. 1 unit. Prerequisite: Biology 110, 111, or Zoology 104, or Botany 100.

SUGGESTED PROGRAMS FOR THE MASTER'S DEGREE

From the courses offered in civil engineering and in other departments, the student may select a variety of programs of study. He is assisted by his adviser in selecting courses which complete his background of fundamental work and advance his knowledge in one of the fields of specialization in civil engineering. The following programs may help the student evaluate the possibilities in specific fields.

Study beyond the degree of Master of Science is an individual matter, and each program is carefully reviewed and selected by the student and his adviser.

Construction Engineering and Management

This program is designed to prepare a student for the profession by further developing his analytical abilities, increasing his capability to recognize and solve a wide variety of construction-management problems, and developing a genuine interest in broadening his scientific horizons. A master's degree program could include courses Civil Engineering 314 through 318, 391, 416, and 417; Mathematics 363; and approved electives or thesis.

Hydraulic Engineering

Courses in hydraulic engineering are available to graduate students specializing in the areas of hydromechanics, hydraulic structures, hydrology, and water resources. Recommended programs emphasize the study of basic subjects and yet provide flexibility to pursue a well-balanced curriculum to meet the needs of the individual students background and interest. Areas in which a student may select electives are groundwater geology, economics, mathematics, statistics, sanitary engineering, theoretical and applied mechanics, and computer applications.

A typical program leading to a master's degree in civil engineering, in the areas of hydromechanics and hydraulic structures, could include these courses: Civil Engineering 351, 353, 450, 458, 495 (seminar), 497, and approved electives. For students pursuing a master's degree in the areas of hydrology and water resources, Theoretical and Applied Mechanics 335 may replace Civil Engineering 351, and Civil Engineering 352 would replace Civil Engineering 353.

Photogrammetric Engineering

A wide range of courses in this area provides the student the option of selecting either a specialized program in photogrammetry or a broad program in the general field of photointerpretation and photogrammetry. Sufficient flexibility is maintained in either program to provide the candidate with a combination of courses to best meet his individual capabil-

ities and needs. In photogrammetry, a recommended program could include Civil Engineering 391, 403, 404, 497, or 499, and electives would include Mathematics 315, 363, and 387. In a program involving photo-interpretation and photogrammetry, a student could take Civil Engineering 383, 384, 385, 403, 404, 497, or thesis, and the electives could include Geography 378 and Geology 301.

Sanitary Engineering

Proper selection of electives provides the student with the option of selecting either a broad program in sanitary engineering or concentration in one of three special areas: water supply and pollution control, radiological health, or air pollution. A master's degree program would include courses in civil engineering and approved electives in microbiology, chemistry, mathematics, nuclear engineering, physics, physiology, fluid mechanics, or other fields. A typical program could consist of Civil Engineering 345, 440, 442, a sanitary engineering laboratory course, a biology course, and approved electives.

Soil and Rock Mechanics

The student, by proper selection of courses, may obtain a broad background for design and construction in earth and rock materials, or he may specialize in the static or dynamic properties of soils and rocks, in field behavior, or in principles of design. A typical program leading to the Master of Science degree might include Civil Engineering 383, 384, 385, 391, 480, 481, and 484; and Geology 450 and 493.

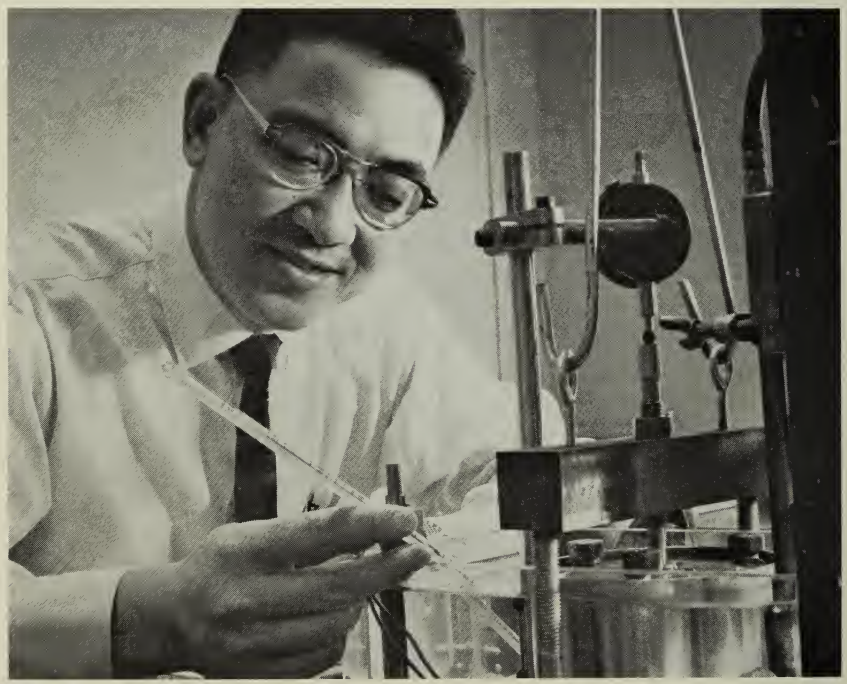
Structural Engineering

Courses offered in this field may lead to specialization in reinforced concrete and structural metals, theory and analysis, structural and soil dynamics, nuclear structural engineering, and other areas. A typical balanced program would include one or more units from civil engineering courses in: Structural Analysis (Civil Engineering 461, 470 through 474, and 478 and 479); Structural Design (Civil Engineering 369, 465, 468, 476, and 477); Behavior of Structures (Civil Engineering 366, 467, and 475); Soil Mechanics and Foundation Engineering (Civil Engineering

383, 384, and 480 through 485); and Computer Aided Design (special courses). In addition, a balanced program should include one or more units of electives from such areas as mathematics, theoretical and applied mechanics, or physics.

Systems Analysis and Design

This program in civil engineering is founded upon two precepts inherent in the systems approach. First, the ability to make the proper decisions is based upon the logical process of analyzing factual information and structural techniques; and second, the engineer learns how to resolve civil engineering problems by applying information processes founded upon mathematical concepts of probability, statistics, network theory, matrix theory, and linear programming. A balanced program for a master's degree includes at least four units selected from Civil Engineering 314, 315, 316, 318, 352, 391, 450, 452, 470, 478, 492, and 497. Approved elec-



Professor Thomas K. Liu is using a constant temperature oedometer to study the influence of organic material on the consolidation characteristics of cohesive soils.

tives include Economics 374 and 474, Industrial Administration 312, and Mathematics 361.

Transportation

A wide variety of courses are offered which cover engineering and related activities in the field of transportation. The graduate student may select a program dealing with the concepts and problems common to all modes of transportation such as planning, systems design, and operations; materials, and structural design of roadways; or he may choose a program related to a specific mode by taking courses in highway traffic engineering or railway engineering. A normal program would include basic and related civil engineering courses and approved electives offered by other departments. Students may select a program of courses from the following groups.

Planning, Systems Design, and Operations. This deals with the concepts of planning a transportation system and the technological aspects of design and operation of the systems. Basic courses in civil engineering are Civil Engineering 322 through 334, 336, 338, 426, 497, or 499. Related courses are Civil Engineering 314, 316, 416, 427, 428, 436, or 494. Elective courses may be selected from economics, geography, mathematics, or urban planning.

Materials and Structural Design of Roadways. This concerns the theories and behavior of materials and soils as related to the structural aspects of transportation facilities. Basic courses in civil engineering are Civil Engineering 321, 335, 368, 369, 383, 384, 420, 421, 422, 426, 435, 482, 485, 495, 497, or 499. Related courses are Civil Engineering 322, 325, 366, 427, or 473. Elective courses may include computer applications, geology, industrial engineering, or theoretical and applied mechanics.

Highway Traffic Engineering. Basic courses in civil engineering are Civil Engineering 325, 332, 426, 427, 428, 495, 497, or 499. Related courses are Civil Engineering 302, 316, 333, 416, 417, 420, 421, 456, or 494. Elective courses may include economics, geography, sociology, or urban planning.

Railway Engineering. Basic courses in civil engineering are Civil Engineering 335 through 338, 435, 495, 497, or 499. Related courses are Civil Engineering 314, 383, 456, or 485. Electives may include economics or geography.

Urban Planning and Management

With almost 80 per cent of the steadily increasing population in the United States living in urban areas, there is a growing concern at all levels of government, from local to federal, with the many problems created by this urban growth. Civil engineers are directly and intimately concerned with the physical facilities that make up the urban complex and they are becoming involved in many ways in the planning and management of the urban community. As municipal engineers, public works directors, and city managers, civil engineers need a broad background of advanced training not only in civil engineering, but in many other disciplines which influence their decisions.

The variety of courses offered by these other disciplines at the University of Illinois provides an excellent opportunity for graduate study by civil engineering students interested also in urban planning and management. Because of the variety of combinations possible, specific programs of courses are not listed.

Engineer Officers Programs

A number of special programs for officers in the Air Force, Army Corps of Engineers, and Navy Civil Engineering Corps is available. These programs are designed to meet the particular needs of the different services. Because of the wide variety of courses that are offered, the programs can be tailored to suit the backgrounds, capabilities, and interests of each student officer.

The basic course is one of twelve months' duration which includes advanced work in a broad range of civil engineering study. Other programs, from eighteen to twenty-four months' duration, provide for greater specialization in such fields as structural dynamics, systems analysis (construction engineering, operations research), urban and regional planning, engineering physics, nuclear engineering, and water resources. While all of these special programs include a core of required courses which differs among the several programs, they possess sufficient flexibility, through electives, to permit the development of programs that are compatible with the needs and interests of both the student officers and the Department of Defense services that they represent. Detailed suggested programs may be obtained from the Head of the Department of Civil Engineering.

CALENDAR[1] OF THE GRADUATE COLLEGE

Second Semester, 1966-1967

Feb. 2, Thurs.–Feb. 4 Sat. to 12:00 noon	Graduate registration.
February 6, Monday	Instruction begins.
February 13, Monday	Last day for application for fellowships for 1967-1968.
February 17, Friday	Last day for application to take French examination on March 3.
February 24, Friday	Last day for application to take German examination on March 10.
March 3, Friday	Last day for application to take Russian examination on March 17.
March 3, Friday evening	French examination.
March 10, Friday evening	German examination.
March 17, Friday evening	Russian examination.
March 20, Monday	Last day for adding a course to program.
March 25, Saturday	Last day for preliminary examination for the Ph.D. degree if theses credit earned during the semester is to apply to the third stage of program.
March 25, Saturday, 12:00 noon	Spring vacation begins.
April 3, Monday, 1:00 p.m.	Spring vacation ends.
April 7, Friday	Last day for application to take French examination on April 28.
April 24, Monday	Last day for application to take German examination on May 5.
April 28, Friday	Last day for application to take French Educacational Testing Service examination on May 20.
April 28, Friday	Last day for application to take German Edutional Testing Service examination on May 20.
April 28, Friday	Last day for application to take Russian examination on May 12.
April 28, Friday	No names will be added to the June graduation list after this date.
April 28, Friday	Honors Day. Classes dismissed at 12:00 noon.
April 28, Friday evening	French examination.
May 5, Friday evening	German examination.
May 12, Friday evening	Russian examination.

[1] The Graduate College catalog contains a detailed calendar of events.

May 15, Monday	Last day for candidates for the doctoral degree in June to submit theses and abstracts to Graduate College Office for approval of format.
May 20, Saturday	French Educational Testing Service examination.
May 20, Saturday	German Educational Testing Service examination.
May 26, Friday	Last day for candidates for the master's degree in June to deposit theses.
May 29, Monday	Last day for finals for the doctoral degree in June.
May 30, Tuesday	Memorial Day (holiday).
May 31, Wed.–June 8, Thurs.	Semester examinations.
June 5, Monday	Last day for candidates for the doctoral degree in June to deposit theses and abstract.
June 17, Saturday	Commencement exercises.

Summer Session, 1967

June 19, Monday	Registration of graduate students not enrolled in the second semester, 1966-1967.
June 20, Tuesday	Instruction begins.
June 20, Tues.–June 21, Wed.	Registration of graduate students enrolled in the second semester, 1966-1967.
June 30, Friday	Last day for application to take French examination on July 21.
July 4, Tuesday	Independence Day (holiday).
July 7, Friday	Last day for application to take French Educational Testing Service examination on July 29.
July 7, Friday	Last day for application to take German Educational Testing Service examination on July 29.
July 7, Friday	Last day for application to take German examination on July 21.
July 14, Friday	Last day for application to take Russian examination on July 21.
July 21, Friday	French examination.
July 21, Friday	German examination.
July 28, Friday	Russian examination.
July 29, Saturday	French Educational Testing Service examination.

July 29, Saturday	German Educational Testing Service examination.
August 10, Thursday	No names will be added to the August graduation list after this date.
Aug. 11, Fri.–Aug. 12, Sat.	Summer session examinations.
August 14, Monday	Last day for candidates for the master's degree in August to deposit theses.
September 8, Friday	Last day for candidates for the doctoral degree in October to submit theses and abstracts to Graduate College Office for approval of format.
September 22, Friday	Last day to file application for the master's degree in October.
September 22, Friday	Last day for candidates for the master's degree in October to deposit theses.
September 23, Saturday	Last day for finals for the doctoral degree in October.
September 29, Friday	Last day for candidates for the doctoral degree in October to deposit theses and abstracts.

First Semester, 1967-1968

August 2, Wednesday	Last day for foreign students who have *not* attended a college or university in the United States to apply for admission in September, 1967.
August 30, Wednesday	Last day for domestic students, or foreign students who have attended a college or university in the United States, to apply for admission or readmission in September, 1967.
Sept. 14, Thurs.–Sept. 16, Sat. to 12:00 noon	Graduate registration.
September 18, Monday	Instruction begins.
Nov. 9, Thurs.–Nov. 10, Fri.	Dedication of the Civil Engineering Building.
November 22, Wednesday, 1:00 p.m.	Thanksgiving vacation begins.
November 27, Monday, 1:00 p.m.	Thanksgiving vacation ends.
December 22, Friday, 1:00 p.m.	Christmas vacation begins.
January 3, Wednesday, 1:00 p.m.	Christmas vacation ends.
Jan. 15, Mon.–Jan. 23, Tues.	Semester examinations.

UNIVERSITY OFFICES

Office of Admissions and Records
100a Administration Building
Urbana, Illinois 61801

Graduate College
330 Administration Building
Urbana, Illinois 61801

Department of Civil Engineering
Civil Engineering Building
Urbana, Illinois 61801

Housing Division
420 Student Services Building
Champaign, Illinois 61820

Office of Foreign Student Affairs
310 Student Services Building
Champaign, Illinois 61820

University offices are open Monday through Friday
from 8:00 a.m. to 12:00 noon and
from 1:00 to 5:00 p.m. except on holidays.